A TWELFTH-CENTURY FALDSTOOL

From the early twelfth-century Vatican MS. Lat. 4939 containing Beneventan Annals

S. P. E.

TRACT No. XXXII

THE
B.B.C.'s RECOMMENDATIONS FOR PRONOUNCING DOUBTFUL WORDS

Reissued with Criticisms

Edited by

ROBERT BRIDGES

AC OX

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PLATES

ON THE SCHEME AND CONTENTS OF THIS TRACT

In a previous Tract, 'The Society's Work', in which we declared the means by which our activities might reach the public, we noticed the new influence of Broadcasting, which has sprung up as a sort of rival to journalism; speech *v.* spelling. We recognized it at once as a new and strong ally which would affect practice, and it has not disappointed our expectations. The Broadcasting authorities soon found their Announcers in doubt concerning the pronunciation of many words that they were obliged to use. It was not that they could not pronounce them or were unaccustomed to them, but they were aware of alternative pronunciations, in the presence of which they were not confident of their own, and rightly wished to be in order. This is like the difficulty about spelling that besets Editors, who, producing work for the public eye, have to instruct their printers to observe certain fashions of orthography. The action taken by the B.B.C. is described in Prof. Lloyd James's able preface to their paper on 'Broadcast English',[1] which is incorporated in this Tract: from which the reader will see that the pronunciations recommended to their Announcers were extorted to meet a practical difficulty, and not advanced as authoritative final decisions of etymological correctness. But though concession to common use was necessary, the whole procedure was on the scientific lines which our Society has always advocated.

In that same Tract XXI, referred to above,[2] we wrote:

'Our first and most essential tenet was to have a popular and not an academic constitution; to proceed that is by inquiry and discussion rather than by authority. No success can be looked for without the goodwill of the public, whose goodwill can only be won by reasonable persuasion. Principles must be demonstrated to common-sense and their application logically displayed.'

[1] The Committee, mentioned in the Director's foreword, may seem to be a small body; but though they are the only responsible persons, the table, whenever I attended the meeting, was always a very full one.

[2] It should be noted that we did not consider disputed pronunciation of particular words a subject in which we were primarily interested.

And again, in the preliminary programme of our first Tract (I, p. 11):

'We shall therefore not insist on any doubtful or disputable detail as a rule of correctness; but we shall rely on suggestion, believing that we shall attain the best results, by causing those who lead the fashion to consider the problems and think them out for themselves.'

While then it furthers the object of the B.B.C. Committee to subject their decisions to as wide a criticism as possible, their list of words supplies a most desirable material to work upon. The discrimination of the words that give practical trouble, and the actual definition of their disagreements, is a piece of good fortune which makes a step on to firm ground which could hardly have been arrived at in a simpler way.

Wishing to make the most of this rare opportunity, I found that the B.B.C. welcomed my proposal to deal with their booklet as will be done in this Tract: and in order to obtain independent and weighty opinion I invited the criticism of some of our best speakers, including Lord Balfour (an original member of our Society, whom we may here thank for his valuable and long-continued support and especially for his generous assistance on this occasion), and Earl Russell, who has long been one of our members, and Lord Grey of Fallodon, who also made friendly response to my call; besides these, Mr. Granville-Barker and Dr. Onions sent me their separate animadversions, making five objectors in all. I call them objectors, but though in one or two cases their objections were strongly expressed they were generally offered as a record of divergent practice and of habitual rather than convinced usage. There would have been more critics if all my invitations had been accepted; but what was obtained is sufficient to work on. It will here be summarized and displayed with the intention of introducing our readers to the actual problems and principles of their solution.

We beg those who wish to bind up our Tracts to excuse the discontinuous pagination of the B.B.C. paper, for the free gift of which we return our grateful thanks to the Director of the company. Our analysis and remarks will find their place at the end of it.

BROADCAST ENGLISH

I

RECOMMENDATIONS TO ANNOUNCERS REGARDING CERTAIN WORDS OF DOUBTFUL PRONUNCIATION

With an Introduction
by

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THE BRITISH BROADCASTING
CORPORATION
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Foreword

SINCE the earliest days of broadcasting the B.B.C. has recognised a great responsibility towards the problems of spoken English. These are vexed but intriguing. They might have been evaded, leaving both general principles and particular words to chance. Tendencies might have been observed and either reinforced or resisted. As the broadcaster is influential, so also is he open to criticism from every quarter in that he addresses listeners of every degree of education, many of whom are influenced by local vernacular and tradition. There has been no attempt to establish a uniform spoken language, but it seemed desirable to adopt uniformity of principle and uniformity of pronunciation to be observed by Announcers with respect to doubtful words. The policy might be described as that of seeking a common denominator of educated speech.

With this in view, the B.B.C. decided in 1926 to seek expert advice, and was fortunate enough to secure the active co-operation of a Committee under Mr. Robert Bridges, the Poet Laureate, as Chairman, with the following members: Sir Johnstone Forbes-Robertson, Professor Daniel Jones, Mr. A. Lloyd James, Mr. George Bernard Shaw, and Mr. Logan Pearsall Smith. The Committee has held several meetings, as a result of which it has enunciated certain principles for general guidance, and has considered some hundreds of words of which the pronunciation is doubtful. The present pamphlet is the first official publication embodying the findings of the Committee. It remains for me to commend it to the listening public and to thank the Committee for their assistance, and in particular Mr. A. Lloyd James, whose labours as Honorary Secretary have been indefatigable.

J. C. W. REITH,
Director-General.

BROADCAST ENGLISH

GENERAL CONSIDERATIONS

THE language that had its birth in these islands, and was for centuries confined to them, is now more widely spread over the world than any other language; and its history is an epitome of the nation's history. We who speak it, however, are but little concerned with its past; we are responsible, though unconsciously, for its present, and we steadfastly refuse to contemplate its future. In our study of the growth of the Empire we forget that this territorial expansion of our language sowed the seeds of its disintegration. In our review of the social advancement of the nineteenth century, we forget that compulsory education and universal reading have begun to break up our historic dialects, and given to the printed word a degree of authority that it never possessed before. In our outlook upon the future we cherish the delusion that our language will remain as we know it now, the optimistic even seeing in it a future world-language.

It requires a peculiar refinement of the historical sense to see history in our every-day life, and an exercise of the imagination to see in broadcasting a feature of our national life that may have a permanent influence upon our language. It is not improbable that this general dissemination of the spoken word may tend to counteract the disintegrating influences that have hitherto always disturbed the unity of a language when that language has, through the political expansion of a nation, become scattered over an area larger than that which gave it birth.

STYLES OF SPEECH

But however indifferent we are to language as a whole, most of us are far from indifferent to our own speech. On the contrary,

it is nowadays considered essential that those who aspire to be regarded as cultured and educated should pay a due regard to the conventions that govern cultured and educated speech. It would appear that this interest in the niceties of our language is more alive now than ever before, and it has been suggested that broadcasting is in some way responsible for this quickening.

We now have a certain type, or rather a carefully chosen band of types of English, broadcast over the length and breadth of our country, so that, although many listeners hear daily a type of speech with which they are familiar, and which they habitually use, many others hear a type that is different from that which they usually hear and use. This in itself is enough to ensure abundant criticism: the man who is familiar with the broadcast pronunciation will be inclined to criticise any discrepancy between it and his own. The man who realises that the pronunciation of the loud-speaker is not his own, and not one that he hears about him in his every-day life, may resent the fact that an alien dialect is inflicted upon him. The one may accuse the broadcast speaker of ignorance or affectation: the other may make a general condemnation of the unfamiliar speech, calling it cockney, or Manchester, or Oxford. There are, for instance, current in modern English many ways of saying the word "dance": they can all be divided into two main classes, viz.:

(i) those that use the short vowel of "Dan,"
(ii) those that use the long vowel of "darn."

Speakers who use the first variety often accuse the others of being cockney: those who use the second accuse the others of being provincial. Criticism does not end here, for those members of either group whose precise shade of vowel sound is not to the satisfaction of other members of the same class may be called affected, or uneducated.

The Englishman claims many birthrights, not the least of which is his right to speak his own language as, subject to the good-will of his friends, it pleases him to do; perhaps next in importance

must be ranked his right to think whatever he pleases of any style of speech that is different from his own. Every man is a law unto himself in this matter, having one standard of conduct and one alone—that which he and his fellows invariably do, this being, for that reason, the right thing as far as it concerns him. He dresses like his fellows, and any conspicuous variation in the colour or shape of a garment is usually ridiculed: the style associated with one class, or with one occasion, is not deemed fitting in another class, or upon a different occasion. The kilt is as conspicuous in Piccadilly as the silk hat upon the moors: there are, however, occasions when a black tie is considered suitable by all classes. What is true of dress is in some degree true of speech, for both are governed by local convention and public taste, with a necessary reverence for historical tradition and the original purpose for which they were designed.

Affectation and pedantry are to be found wherever language is spoken; they are not confined to any one local or class variety of speech. The indiscriminate use of *h*, for instance, among some uneducated speakers is a pretension to superiority that may merely amuse us. Such pronunciations as *nevaa*, *faa*, *waaliss*, for *never*, *fire*, *wireless*, will appear an offensive affectation to those who are unacquainted with the class variant of which these pronunciations are so characteristic a feature.

Perhaps it may help us to view this question of taste in language in its proper setting if we realise that it is the same, in its fundamental principle, all the world over. Even in the primitive communities of Africa there are dialects, and it is often a matter of grave concern, when the language has to be written for the first time, and books have to be printed, which particular dialect shall be chosen. The speakers of all but the chosen one will resist the attempt to force upon them and their children a fashion of speech which is not that of their tribe, of their fathers, of the heroes of their legend.

Local pride and prejudice in speech, therefore, are not confined to the more civilised communities; it would appear, however, that the higher a community climbs in the social scale, the greater is the degree of uniformity in the speech. Wherever language is

spoken, there is present in the minds of the speakers the notion that there is a "right way" of speaking it, and the larger the community using the given language, the greater the number of "right ways." Every district will have its "right way"—not that the speakers of that district will think of it as a "right way"; they merely conform to the local way. Every social class will have its "right way," so much so that a man's social class will be more evident from the fashion of his speech than from any other fashion he adopts. So it is with English, and since English is, geographically, the most widely spread language in the world, it follows that the problems common to all languages are more acute here than they are elsewhere. It needs but little imagination to realise that when oral communication with all parts of the English-speaking world becomes, through the wireless medium, a daily event, there will have to be a greater degree of toleration shown towards the language of the loud-speaker than is at present shown by some of its critics. But though we may say that "correct" and "right" are not proper terms to use in these questions of pronunciation, yet there are exceptions; for where the different considerations of propriety, instead of conflicting, all lead to the same conclusion (and that is not uncommon), we may conveniently use the terms right and wrong.

The question of a *standard pronunciation* is bound to arise wherever language is spoken. English has a further question, arising from the absence of any recognised authority in its pronunciation. This is the question of *alternative pronunciations*. The two questions are intricately connected, but we may for convenience examine them separately.

1. *Is there a standard dialect of English?*

The listener who writes to the B.B.C. asking why the London announcer pronounces "d a a n c e" for "dance" is, in reality, protesting against having an alien fashion of speech thrust upon him. The listener who complains that the London announcers are obviously affected is registering, in all probability, his protest against having thrust upon him the fashion of speech peculiar to

a class of society, to a locality, or to a type of character, with which he is not in daily touch. Both critics imply that there is a "better way" of speaking than that adopted by the announcers. The listener who writes to ask the "correct way" of pronouncing a word quite evidently assumes that there *is* a "correct way." In all these queries and criticisms there is implied the idea of a standard pronunciation. We have a standard yard, a standard pound weight, a standard sovereign, and a standard pint. The yard does not vary from Aberdeen to Plymouth, and the pint pot contains as much in Mayfair as in Bethnal Green. Unfortunately speech is not capable of rigid measurement, and there is no standard of pronunciation. Pronunciation varies from district to district, from class to class, from character to character, in proportion to the local, social, or moral difference that separates them. Certain general observations may be made upon this aspect of the question without going into details, *e.g.* :—

1. There are district variants of speech in every social class, and class variants in every district.
2. Local variants become increasingly unlike one another as we descend the social scale.
3. They become more alike as we ascend.
4. The greater mobility of educated people tends towards the elimination of some of their local peculiarities.
5. The general spread of education tends to bring about the unification of the social variants in all districts.
6. Out of the broad band that comprises all district and class variants, there is emerging a considerably narrower band of variants that have a very great measure of similarity.
7. This narrow band of types has more features in common with Southern English than with Northern English.
8. Those who speak any one variety of the narrow band are recognised as educated speakers throughout the country. They may broadcast without fear of adverse intelligent criticism.

There may be other conclusions, but it is quite evident that we are not entitled to conclude that there is *one* standard pronunciation, *one* and *only one* right way of speaking English. There are varieties that are acceptable throughout the country, and others that are not.

2. *Alternative Pronunciations.*

Germany has attempted to lay down certain principles to be followed by actors in the countries where German is spoken: it is obviously desirable that two members of the same cast should, unless it is expressly desired that they should not, speak the same variety of German. The Conservatoire in Paris, with the support of the National Theatres and the State Opera, exercises a control over the style of pronunciation to be used on the stage. In both these countries there is a "right way," or at any rate a very powerful tradition.

In Great Britain there is no such officially inspired authoritative tradition, and consequently our language is particularly rich in alternative pronunciations of equal authority. The B.B.C. has no desire to accept or to dictate any standard of pronunciation other than the current usage of educated speakers. But where there is diversity of opinion among works of reference, and diversity of practice among educated speakers, it is evident that no solution of doubtful questions can be attained that will meet with universal approval. The function of the Advisory Committee on Spoken English is to suggest to the Corporation, for the use of announcers, solutions that shall be in accordance with one accepted usage.

With the question of a standard language, this question of alternative pronunciations is involved, and the relationship between the two questions is best understood by reference to particular cases. Is *dance* to have the long vowel or the short vowel? Speakers of the Northern acceptable varieties favour the short vowel, while Southerners favour the long. Both pronunciations must stand: both are common among educated speakers. It is probable that the Southern variety will prevail, merely

because it is the Southern variety, and is current in the metropolis. There is no standard dialect, but here, as in all communities, the educated speech of the capital starts with a heavy handicap in its favour.

Is *laboratory* to have the accent on the first syllable or on the second? Here there is no question of district variants: the two pronunciations are heard in all parts of the country. This is a question of alternative pronunciations, and, since most of the work of the Advisory Committee is concerned with alternative pronunciations, it will be well to examine very briefly the causes that give rise to these alternatives in our language.

VISUAL AND SPOKEN LANGUAGE

To begin with, it must be borne in mind that the language of a modern civilised community embraces the *spoken* or *oral* language, and the *written* or *visual* language. The visual language is generally an attempt to represent by means of visible symbols the sounds of the spoken language. Since it is impossible to make sounds visible, it follows that the relationship between the sounds and the symbols must be a conventional one; furthermore, since the same set of symbols has to serve for all the local and class variants of any given tongue, there will be a variety of conventions. Observance of these conventions is what is known as correct spelling; and, as a general rule, it may be stated that the greater the degree of uniformity prevailing in the conventions of any language, the simpler is its spelling, which is but another way of saying that the language is highly *phonetic*.

The arts of reading and writing are, in essence, nothing more than the understanding and the observance, respectively, of the conventional relationships that exist in language between the sounds used in the spoken language and the symbols used in the written language to represent these sounds The conventions are necessary because sound and sight are fundamentally different; no system of symbols can ever represent speech adequately or accurately.

Visual languages are of two main kinds, viz.—

(*a*) those in which no attempt is made to represent the sounds—Chinese;
(*b*) those in which some such attempt is made—English, Greek, Sanskrit.

Languages of the first class require a separate sign for every word; reading and writing are not possible until the beginner has learned some hundreds of signs. It takes a Chinese student many years to learn the thousands of characters he requires in order to read a newspaper.

In languages of the second class an attempt is made to represent the pronunciation by means of letters, each of which is supposed to have a certain value when translated into sound. There are usually more sounds than letters, with the result that the ideal of one sound per letter is seldom attained—unless indeed this happy state prevails in Korean. The same letter may have several values: *e.g.* the letter "s" stands for the "s" sound in *picks*, for the "z" sound *pigs*, and for the "zh" sound in *measure*. The same sound may be represented in many ways; *e.g.* the "f" sound is represented by "f" in *feel*, by "ph" in *philosophy*, and by "gh" in *laugh*. A single letter may stand for one or more groups of sounds; thus the letter "x" represents the sounds "ks" in *six*, and the sounds "gz" in *exist*. A single sound may require a group of letters, and the same group of letters may represent several sounds: *e.g.* the two letters "th" represent one sound in *thick*, another sound in *then*, and yet another sound in *thyme*.

These discrepancies arise from the very simple fact that a language may have more sounds than letters. English uses the Roman alphabet, with certain additions, and has twenty-six letters to do duty for its sounds. Our language comprises at least thirty main essential sounds, for which symbols are indispensable. Unless a language is fortunate enough to have an alphabet that can provide one letter per sound, then there is bound to be established a conventional relationship between some sounds and some symbols. In time the conventions are observed differently by different districts, and variant pronunciations will begin to arise.

No system of symbols, then, can represent a system of sounds without a series of conventions; and it follows, therefore, that the ideally phonetic language does not exist. This truth must have been realised very early, for, although written language starts as an avowed attempt to reproduce the spoken language, it soon abandons the effort, and tends more and more as time goes on to persist unchanged, ceasing to register the very considerable ravages made by time upon the spoken idiom. The havoc wrought upon the sounds of our language before our own time is accepted complacently, but we are all inclined to resist vigorously the inroads that are being made in our own day.

We are thus faced with the additional anomaly that the visual language is not really a picture of the language as it is now, but rather of the language as it was when the visual language began to become popular. In the case of English, we possess in our visual language a picture of what our pronunciation was, in its main features, in the century that immediately succeeded the introduction of printing.* The further removed we are in time from the date of the popularisation of our visual system, the greater will be the discrepancy between the spoken and the written languages. Tibetan orthography was fixed in the seventh century, and is still current as then fixed, so that a word which appears written as *dbyus* is pronounced "ü." In our own time the word written *plough* is now spoken as *plow*, *rough* is spoken as *ruff*, *cough* as *coff*. What we now see as *dough*, we speak as *dō*, having to make a new word to represent a pronunciation that the letters "dough" once represented. The new word is *duff*. Sound and symbol are by their very nature irreconcilable, and their very nature serves to make them still more irreconcilable as time progresses. Sounds are vague and ethereal things that cannot be crystallised: they arise, in language, from muscular habits of the organs of speech, and change from generation to generation with a constancy in which some scholars have professed to see the regularity of natural law. The inevitable law of spoken language is change, because

* In English, the main features of our spelling became fixed in the sixteenth century, so that the far-reaching changes in our pronunciation which took place during the next three centuries are, of course, unrecorded in our orthography.—WYLD, *Historical Study of the Mother Tongue*, p. 15.

sound is sound, and because the impression of sound upon the mind is not as enduring as the impression of sight. The equally inevitable law of written language is persistence, because the eye has become accustomed to see, and the hand to make, certain signs in certain orders, and the mind has become accustomed to read them silently with little or no reference to the sounds they were intended to represent. Any alteration of the existing visual language will disturb the smooth working of two processes, reading and writing, that have taken years to bring to perfection. It is conceivable that the two processes would be more easily acquired if there were some attempt to reconsider the conventional relationships existing between sound and symbol; it is possible that if no such reconsideration ever takes place, the discrepancy between spoken and written language will increase with time until the conventions are so numerous that there will be one convention per word, as in modern Chinese. As against this, it is not surprising that there is now a steadily increasing tendency to make the visual language a standard, and to pronounce words, not according to their later acquired pronunciation, but according to their traditional spelling. Whereas the writing was originally designed to represent the sounds, we are now trying to make the sounds conform to the symbols. Thus there has come about a strange inversion of the original processes.

This discrepancy between sound and symbol, then, is a fertile cause of uncertainty in pronunciation. The letters "ei" have one sound in *eight* and another in *receive*. Therefore we may expect uncertainty as to their value in unfamiliar words, e.g. *inveigle*. It is unnecessary to multiply examples, for many of the alternative pronunciations recorded in English dictionaries are examples of this uncertain relationship between sound and symbol.

FOREIGN WORDS

Into this chaos of conflicting relationships there must be thrown, according to some, a further convention, namely, a relationship between the value of the symbol in the modern language and the value it had in a classical language. *Cinema* derives from a Greek

word that began with the "k" sound, therefore, it is alleged, the English word must have the "k" sound.*

The number of people who are familiar with the original phonetic values of these letters is small; and there is often uncertainty as to what these original values really were. In view of the complicated nature of the already existing relationship between sound and symbol in English, it would appear advisable not to add a further complication by this consideration of ancient values. But so long as this consideration is regarded as desirable, it will be a fertile source of alternative pronunciations.

To some extent the same is true of modern foreign languages from which our vocabulary continues to enrich itself. What is to be done with the countless words that come to us from these sources? Are we to keep the foreign pronunciation? Or are we to read the words as though they were English words? This question bristles with difficulties, and little can be said about it here, beyond registering the view that the question is not one to be dismissed in the summary way that is not uncommon. In early days such words were read as English words. French was read as though it were English, and the matter ended there. But since we have begun to learn French and to speak it with some attempt at giving our effort a French sound, it is thought desirable to give French words as near an approximation to their French pronunciation as possible. The approximation is often a poor one, because French sounds are not English sounds, and because the rhythm and accent of French are alien to English. So it comes about that however laudable our intention to preserve the French pronunciation, the result is a collection of those already existing English sounds that most nearly approximate to the French. The only French sound in the average English pronunciation of the word *restaurant* is the "s," which is the same in English and French.

* About the middle of the last century the classicists made a conscientious effort to "improve" the traditional English pronunciation of words derived from Greek and Latin, by fitting them out with what they thought were the original sounds. The rightness of this procedure was then so little questioned that there was a sort of shamefaced panic among scientists who had not learned the dead languages. The principle involved is now rightly discredited: we preserve one or two acceptable results, but in most cases have to deplore pedantic anomalies. [R. B.]

In the case of other languages less familiar than French, there is usually less attempt to reproduce the native pronunciation, especially when that attempt involves the production of sounds which are usually considered difficult. Most people are aware that the initial consonant in the name *Wagner* sounds like an English "v," and most of us pronounce it as such, because there is a "v" sound in English. *Bach* is less fortunate, for his name contains a sound that English people have forgotten for some centuries how to make; he is therefore frequently called *Baak*. The further afield we travel, the more hopeless becomes the attempt to reproduce the native pronunciation, and he would be a bold man who would recommend that we should adopt the initial sound that the Arab uses in the word *Koran*, or the initial click that the Zulu uses in *Cetewayo*. A language will seldom accept or embody either sounds or rhythms or accents that are alien to those which are its historical heritage. Isolated speakers may use these exotic sounds, but the bulk of the people will reject them.

POSITION OF STRESS

There must also be noticed another source of alternative pronunciations with which the Advisory Committee is very much concerned. This is the nature and position of the stress or accent in modern English. Concerning the nature of this stress, little is known beyond the fact that its function is to give prominence to certain syllables; these syllables tend in connected speech to recur at regular intervals of time, this regularity constituting that essential feature of our language, its rhythm. This prominence, which is popularly believed to be due to loudness, may owe its origin to other sources. For example, the syllable may be made prominent by its tone, by its length, or by the quality of the vowel sound it contains. What is important to remember is that any question concerning stress *may* be concerned with length or vowel quality.

As to the position of the stress, English offers an example almost unique in the world of languages, for there is no known principle that governs the incidence of stress. The words *photograph*, *photographer*, *photographic*, have the stress on the first, second and third syllables respectively. Some words, e.g. *convict*, *increase*, are

nouns if the stress falls on the first syllable, and verbs if it falls on the second syllable. We are all agreed as to where the stress falls in many words, e.g. *agree*, *belong*, *prominent*, *independent*. But there is no uniformity with regard to *magazine*, *apologise*, which differ in the North and South, or with *laboratory*, *peremptory*, *gyratory*, *applicable*, *indisputable*, and hundreds of others. There would appear to be a popular tendency to place the stress in long words as near to the beginning as possible, with the result that the remaining syllables suffer by the distortion or loss of their vowel sounds. The only disadvantage of this tendency is that the resultant distortion or loss of unstressed vowel sounds frequently brings into awkward contact numbers of consonants, and leads, especially in broadcast speech, to confusion and unintelligibility. *Laboratory* when broadcast with the stress on the first syllable is liable to be heard by a listener as *lavatory*; it is therefore desirable, at any rate in broadcast speech, to avoid throwing the stress too far back. Against this tendency to throw back the stress as far as possible, there is also another principle which is active in determining the accent of polysyllables; that is, the utilitarian principle of keeping the original accent of the root on all its derivatives. This latter principle seems now in favour, driving out older pronunciations, but as it cannot be always observed it will have to win its victories word by word, in the general rub: thus *indispútable* is winning from *indísputable*, because of *dispute*. For an example of anomalies, compare *omniscience* and *omnipotent* with *omnipresence*.

RELATIONSHIP BETWEEN STRESS AND SOUND

There remains finally to be mentioned the relationship between the stress and the quality of the vowel sound in English. This may best be understood by considering an example. The vowel in the word *man*, as the word is said usually, possesses a certain acoustic quality and a certain length; if the word is placed in a position where it does not carry what we know as the stress, e.g. *postman*, the quality and length of the vowel are altered. The stressed vowel is different from the unstressed vowel: indeed, as we have said, this difference of itself may constitute no small part

of the nature of the English stress. This difference is not due to any carelessness of speech; it is an inevitable consequence of that very peculiar feature of our language known as the stress or accent. Any attempt to pronounce English, giving to the unstressed vowels the exact quality they possess when stressed, results in a pronunciation that is not recognisable as English. The degree of difference between stressed and unstressed vowels varies in different parts of the country: there is usually less difference in Yorkshire than in London, with the result that, or possibly because of the fact that, the rhythm of Yorkshire English is different from that of London English. It is impossible to say which is cause and which is effect.

This modification of the vowel sound of unstressed syllables is a source of much anxiety to those who are concerned with speech. Most of us agree that the final vowels of *singer*, *actor*, *banana*, are the same in sound, although they are differently represented in writing. Some speakers rhyme *palace* with *Paris*, *audible* with *laudable*; others make a difference, being guided by a recollection of the appearance of the words. Speakers who hear unstressed vowels that differ from their own are inclined to be very critical, asking, for example, why *wireless orchestra* is pronounced *wireliss orchistra*.

The unstressed vowels in English are working out their own destiny, and it is impossible to predict what the future has in store. One has only to compare the havoc wrought upon unstressed vowels in other languages, *e.g.* French, to realise that in a language that has a strong stress the quality of the stressed vowel is but little guide to the quality of the same vowel when it is unstressed. The Advisory Committee believes that this distortion should be as little as is consistent with the rhythm of Southern English.

CONCLUSION

It will be seen that the question of making any decisions upon English pronunciation is not one to be investigated without much thought. The considerations that have been outlined in this introduction are, so to speak, the academic or scholastic back-

ground of the problem, and with these the average educated speaker of the language is rightly not much concerned. But they are the considerations that are ever present in the minds of those who are responsible for the pronunciations recorded in our standard dictionaries.

But dictionaries disagree among themselves, some offering alternatives that others ignore, some giving first choice to one alternative, some to another. If the B.B.C. quotes one standard dictionary, the critic quotes another, and there is no end to argument.

Moreover, dictionaries grow out of date: the Oxford English Dictionary has been some forty years in the making, and its early volumes already need revision. New words appear that are not recorded in the early volumes; new pronunciations of old words arise, and gain so great a measure of currency that they must be admitted into our speech. For it must not be forgotten that a pronunciation is not bound to be "right" merely because it appears in a dictionary: it appears in the dictionary because it *was* "right" in the view of the lexicographer at the time when he made his dictionary.

Most of the words that follow admit of more pronunciations than one; they are all words that have caused difficulty to announcers, or words that have given rise to criticism from listeners. The Advisory Committee on Spoken English has discussed each word on its merit, and it recommends that announcers should use the pronunciations set out below. It is not suggested that these pronunciations are the only "right" ones, and it is not suggested that any special degree of authority attaches to these recommendations. They are recommendations made primarily for the benefit of announcers, to secure some measure of uniformity in the pronunciation of broadcast English, and to provide announcers with some degree of protection against the criticism to which they are, from the nature of their work, peculiarly liable.

The representation in print of pronunciation is always a difficult matter; it is easy when a complicated phonetic alphabet is employed, but such an alphabet requires special types, and is,

moreover, difficult to read. But unless a phonetic alphabet is employed, there must be a lack of consistency and indeed of accuracy. The pronunciations set out below are indicated as simply as possible, and the original spelling is interfered with as little as possible.

The only general convention that has been observed is that the doubling of a vowel letter indicates a long vowel sound, while the doubling of a consonant letter indicates that the previous vowel sound is short.

The long "o" sound, as in *no*, is represented by ō; the sign ˘ is used to denote a short vowel when the doubling of the following consonant is not convenient. The position of the stress is indicated by the mark ′ over the stressed syllable.

Where the pronunciation can be shown by a note of explanation, this has been done.

A. Lloyd James.

LIST OF WORDS

ACCESSORY	stress on 2nd syllable.
ACCOMPLISH	accómplish, not -cum-.
ACETIC	aséetic.
ACOUSTIC	acóostic.
ADHERENT	adhéerent.
ADIEU	adéw.
ADULTS	áddults.
AERATED	áy-erated.
AERIAL	(*a*) noun—1st syllable to be pronounced áir; (*b*) adjective—ay-éerial.
AEROPLANE	áiroplayn; the Committee advises the use of the word *airplane*.
ALABASTER	stress on 1st syllable.
ALLIES	stress on 2nd syllable.
ALTERCATE	stress on 1st syllable, which is áwl-.
AMATEUR	ámaterr; final syllable rhymes with *fur*.
ANGLICE	ánglissy.
ANTIQUARY	stress on 1st syllable.
APPARATUS	stress on 3rd syllable, which is pronounced as *eight*.
APPARENT	appárrent.
APPLICABLE	stress on 1st syllable.
AQUATIC	akwátic; 2nd syllable rhymes with *hat*.
ARID	árrid.
ARMISTICE	stress on 1st syllable.
ARTISAN	stress on last syllable.

ASPIRANT	stress on 2nd syllable, which is pronounced as *spire*.
ATE	rhymes with *bet*, not with *bait*.
AULD LANG SYNE	*Syne* is to be pronounced like *sign*: the *s* is not to be pronounced *z*.
AUTOGYRO	awtojýro.
AUTOMOBILE	áwtomobeel.
AZURE	ázhure, *a* as in *hat*.
BADE	bad.
BARRAGE	bárraazh.
BASALT	bássolt.
BAS-RELIEF	*s* sounded.
BEDIZEN	rhymes with *horizon*.
BIOGRAPHY	by-ógraphy.
BITUMEN	bíttewmen.
BRUIT	as *brute*.
BUFFET	(*a*) meaning a blow—búffet; (*b*) meaning a refreshment bar—as in French.
CAISSON	casóon.
CALIBRE	cálliber.
CAOUTCHOUC	cówchook.
CAPITALIST	stress on 1st syllable.
CASUALTY	cázewalty, not cázhewalty.
CASUIST	cázewist, not cázhewist.
CATHOLIC	vowel in 1st syllable to be short, as in *hath*, not long, as in Southern form of *path*.
CELTIC	initial consonant to be pronounced *s*, not *k*; the *k* pronunciation is general in Wales.
CENOTAPH	sénnotaaf.
CENTENARY	sentéenary.
CENTRIFUGAL	sentríffewgal.
CERAMIC	serámmic.

CHAGRIN	(*a*) noun—shágrin; (*b*) verb—shagréen.
CHARGÉ	shárzhay.
CHASSIS	shássy.
CHASTISEMENT	stress on 1st syllable; the pronunciation which has the stress on the 2nd syllable (with a long *i*) is obsolescent.
CHAUFFEUR	shṓfer.
CINEMA	sínnemaa.
COGNISANT	cógnizzant.
COINCIDENTLY	stress on -in-.
COMBAT	cúmbat.
COMBATANT	cúm-.
COMBATIVENESS	cúm-.
COMMANDANT	stress on last syllable, which is -ánnt, not -áant.
COMMUNIQUE	comméwnikay.
COMPARABLE	stress on 1st syllable.
COMPLINE	cómplinn.
CONDOLENCE	condṓlence.
CONCERTO	conchérto.
CONGENER	cónjener.
CONGRATULATORY	congráttulaytory.
CONJUGAL	stress on 1st syllable.
CONSTABLE	1st syllable to rhyme with *bun*; the Scottish family name preserves the pronunciation in which the 1st syllable rhymes with *on*.
CONSTRUE	stress on 2nd syllable.
CONTEMPLATIVE	cóntemplaytiv.
CONTRALTO	vowel in 2nd syllable to rhyme with *shall*.
CONTROVERSY	stress on 1st syllable.
CONTUMELY	contéwmĕly.
COQUETTE	cōkétt.
COSTUME	stress on 1st syllable.
COUP	coo.
COURTESY	cúrtesy.

CREDENCE	créedence.
CULINARY	kéw-.
CUNEIFORM	to rhyme with *uniform*.
CURATOR	kewráytor.
DAIL	rhymes with *oil*.
DAIS	dáy-iss.
DATA	dáyta.
DAUPHIN	dáwfin.
DECADE	dékkad.
DECORUM	decőrum.
DECREASE	(*a*) noun—stress on 1st syllable; (*b*) verb—stress on 2nd syllable.
DEFICIT	déffissit.
DEPOT	déppō.
DESPICABLE	stress on 1st syllable.
DEUTERONOMY	stress on 3rd syllable.
DILATE	dyláte.
DILEMMA	dillémma.
DIOCESES	stress on 1st syllable, which is dy-.
DIOCESAN	stress on 2nd syllable, which is -oss-.
DIRECT	dirréct.
DISCERN	dissúrn.
DISHEVEL	dish-évv'l.
DISPUTABLE	stress on 2nd syllable.
DISTICH	dístik.
DIVAN	divvánn.
DIVERSE	dyvérse.
DIVEST	dyvést.
DOCILE	dősyle.
DOCTRINAL	doctrýnal.
DOYEN	dóy-en.
DRASTIC	dráss-, not dráas-.
DYNAST	dínnast.
ELASTIC	eláss-, not eláas-.
ELECTRICITY	1st syllable is ell-, not eel-.

ELEEMOSYNARY	ellimmóssinnary.
ELIXIR	ellíxir.
ELOCUTION	1st syllable is ell-, not eel-.
ELONGATE	1st syllable is eel-, not ell-; stress on 1st syllable.
ELUDE	eeléwd.
EMACIATE	emmáyshiayt.
EMANATE	émmanate.
EMANATION	emmanáyshon.
ENCLAVE	énklayv.
ENNUI	ónwee.
ENSEMBLE	onsómble.
ENTOURAGE	ontooráazh.
ENVELOPE	1st syllable énn-, not ón-.
ENVIRONS	stress on 2nd syllable, which rhymes with *sigh*.
EPHEMERAL	efflémmeral.
EPILOGUE	éppilogg.
EPISTOLATORY	stress on 2nd syllable.
EQUABLE	1st syllable is ekk-, not eek-.
EQUERRY	ékkwerry.
EQUIPAGE	ékkwippage.
ESTHETIC	eesthéttic.
ETIQUETTE	ettikkétt.
EVIL	eev'l.
EVOLUTION	eev-.
EXECUTIVE	egzékkewtiv.
EXILE	éksyle.
EXQUISITE	ékskwizzit.
EYRIE	stress on 1st syllable, which rhymes with *sigh*.
FALCON	fáwkon.
FANATIC	fanáttic.
FANTASIA	fantazéea.
FAULT	long vowel as in *fall*.
FAUTEUIL	főtill; the Committee recommends an English pronunciation.

FECUND	féckund.
FÊTE	fayt.
FETID	féttid.
FETISH	féetish.
FINANCE	finnánce.
FINIS	fýnis.
FORBADE	forbád.
FOREHEAD	fórred.
FORMIDABLE	stress on 1st syllable.
FRAGILE	fráj-ill.
FRONTIER	1st syllable to have the vowel of *front*.
FUNEREAL	fewnéereal.
FURORE	the Committee recommends the pronunciation féwroar, except for the musical term, which is fooróary.
FUTILE	last syllable is -tile, not -till.
GALA	gáala.
GARAGE	gárraazh.
GENUINE	last syllable is -in, not -ine.
GEYSER	géezer.
GLACIAL	gláyshial.
GLACIER	glàss-, not gláas-.
GONDOLA	stress on 1st syllable.
GOUGE	the vowel as in *how*, not as in *who*.
GREASY	gréezy, gréesy. Some people use both pronunciations with different meanings: *gréezy* meaning *slippery*, literally and metaphorically, and *gréesy* meaning *covered with grease*.
GUSTATORY	stress on 1st syllable.
GUTTA PERCHA	*ch* as in *church*.
GYNECOLOGY	initial *g* hard as in *go*.
GYRATORY	jýratory.
GYROSCOPE	jýroscope.
HALLUCINATION	halloocinaýshon.
HAUNT	vowel as in *paw*.

HEGIRA	hédge-irra.
HELIOTROPE	hélliotrope.
HEMISTICH	hémmistik.
HOMOGENEOUS	hommojénneous.
HOSPITABLE	hóspitable.
HOTEL	*h* to be sounded.
HOURI	1st syllable to be *hoo*, not *how*.
HOUSEWIFE	(*a*) of a woman—hóuse-wife; (*b*) the pack of needles, etc.—húzzif.
HOUSEWIFERY	húzzifry.
HOVEL	hóvvel; rhymes with *novel*, not with *shovel*.
HUMOUR	*h* to be sounded.
HYDROGEN	the *g* is soft as in *gentle*.
IDEAL	eye-dée-al.
IDYLL	íddill.
IMMANENT	immáynent, to avoid confusion with *imminent*.
IMPIOUS	ímpĭous.
IMPORT	(*a*) noun—stress on 1st syllable; (*b*) verb—stress on 2nd syllable.
IMPORTUNE	stress on 2nd syllable.
INCREASE	(*a*) noun—stress on 1st syllable; (*b*) verb—stress on 2nd syllable.
INDISPUTABLE	stress on 3rd syllable.
INEXORABLE	innéksorable.
INFINITE	ínnfinnitt; not in-fine-ite; except where metrical considerations require this pronunciation.
INHERENT	inhéerent.
INTESTINAL	intestýnal.
INVEIGLE	inváygle.
IODINE	éye-o-dyne.
IRREPARABLE	stress on 2nd syllable.
IRREVOCABLE	stress on 2nd syllable.
ISSUE	íssew.

JOCOSE	jocóse; *s*, not *z*.
KNOWLEDGE	nólledge.
KORAN	koráan.
LABORATORY	stress on 2nd syllable.
LAMENTABLE	stress on 1st syllable.
LAPEL	stress on 2nd syllable.
LAUNCH	the vowel as in *law*.
LAUNDRY	the vowel in the 1st syllable as in *law*.
LEGEND	1st vowel short as in *ledge*.
LEGHORN	(*a*) applied to hats—Légghorn; (*b*) applied to poultry—Leggórn; (*c*) place name—Légghórn.
LEISURE	rhymes with *measure*.
LEIT-MOTIF	lýt-motéef.
LICHEN	lýken.
LONGEVITY	lonjévvity.
LUCUBRATION	lookewbráyshon.
LUTE	lewt.
LUXURY	lúck-sury.
MACHINATION	mákkináyshon.
MEDICINE	méds'n.
METALLURGY	méttalurjy.
MEDIEVAL	meddy-éeval.
MIDWIFERY	mídwiffry.
MIGRATORY	mýgratory, not—grayt-.
MINIATURE	mínn-yature.
MISHAP	miss-háp.
MISSILE	míssyle.
MONOLOGUE	mónnologg.
MYTHICAL	1st syllable rhymes with *pith*.
NADIR	náydear.
NAIVE	naa-éev.

NEGOTIATE	negṓshiate.
NEGOTIATION	negōshiáyshon.
NEPHEW	névvew.
NOMENCLATURE	nōménclature.
OBDURATE	stress on 1st syllable.
OBESITY	obéesity.
OBLIGATORY	obblíggatory.
OCTOPUS	stress on 1st syllable.
OGIVE	ṓjyve.
OMELETTE	ómmlett.
OMINOUS	ómminous.
OMNISCIENCE	omníssĭence.
OPUS	ṓpus.
ORDEAL	ordéel, not or-dée-al.
ORDURE	stress on 1st syllable.
PACE (Latin, meaning *with deference to*)	rhymes with *racy*.
PALFREY	páwlfry.
PANACHE	pannásh.
PARIAH	párria.
PATENT	páytent, except in *Letters Patent* and *Patent Office*, which have páttent.
PATHOS	páythos.
PATRIOT	páttriot.
PEJORATIVE	péejorativ.
PEREMPTORY	stress on 2nd syllable.
PERFECT	(verb) stress on 2nd syllable.
PETARD	pettárd.
PHARMACEUTICAL	farmaséwtical.
PHILISTINE	fíllistyne.
PIANOFORTE	final *e* to be pronounced.
PLEBISCITE	plébbissit.
POMEGRANATE	pómgranate.

PRECEDENCE	preséedence.
PRECEDENT	(*a*) noun—préssedent; (*b*) adjective—preséedent.
PREMATURE	prémmature.
PREMIER	prémmier.
PRISTINE	prístyne.
PRIVACY	prývacy.
PROCESS	prŏ́sess.
PROGRESS	(*a*) noun—prŏ́gress; (*b*) verb—prōgréss.
PROJECT	(*a*) noun—prój-ect; (*b*) verb—prō-jéct.
PROLOCUTOR	prōlóckewtor.
PROVOST	(*a*) civic and academic—próvvost. (*b*) military—provvṓ.
PULSATE	pulsáyt.
QUANDARY	kwondáiry.
QUEUE	kew.
RAFFIA	ráffĭa.
RATION	rhymes with *fashion*.
RECONDITE	recóndyte.
REDOLENT	réddolent.
REPLICA	répplikka.
REPUTABLE	réppewtable.
RESEARCH	stress on 2nd syllable, which is pronounced exactly as *search*, not *zearch*.
RESPITE	réspit.
REVERBERATORY	principal stress on 2nd syllable, secondary stress on 4th syllable.
ROMANCE	stress on 2nd syllable.
ROTATORY	rōtáytory.
ROUTE	root.
SALINE	(*a*) noun—salýne; (*b*) adjective—sáylyne.

SATIRE	sáttyre.
SATYR	sátter.
SAYS	sez.
SECRETIVENESS	sekréetivness.
SHEIK	shayk.
SIOUX	soo.
SOLDIER	sőljer.
SONOROUS	sonőrous.
SOUGH	rhymes with *plough*.
SOVIET	sővĭet.
SPA	spaa.
SPINET	spinnétt.
SPONTANEITY	spontanéeity.
STATUS	stáytus.
TATTOO	stress on 2nd syllable.
TEMPORARILY	stress on 1st syllable.
THRENODY	thréenody.
TORTOISE	tórtus.
TRAIT	trayt.
TRAVERSING	trávversing.
TROUGH	troff.
TRYST	vowel as in *rice*.
UNPRECEDENTED	unpréssedented.
UNTOWARD	untő-erd.
UPANISHAD	oopánnishad.
VALET	vállett.
VEHEMENT	véehement.
VIA	vý-a.
VICTUALLERS	víttlers.
VIKING	výking.
VIOLA	(*a*) musical instrument—vĭőla; (*b*) flower—výŏla.
VITUPERATION	vittewperáyshon.

WESLEYAN	wésslĭan.
WONT	wōnt.
WRATH	rawth.
WROTH	rōth.
ZOOLOGICAL	zō-ŏlój-ical. In *Zoological Gardens* the word is pronounced zoo-lój-ical.
ZOOLOGY	zō-óll-ogy.

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[No. 239]

NUMERICAL STATISTICS

THE first thing which everybody will wish to know is the percentage of objections against the B.B.C. decisions. (It will be noticed that the list was submitted separately to five persons for their opinions.) The whole number of words in the list is 322 and, marking all those to which any objection was raised, we discover that as many as 99 are questioned. This high proportion, if the authority of the critics be considered, might seem to discredit the Committee's findings; but we must remember that all the words in the list are in a doubtful condition, and it is some satisfaction to find that 223 have full consensus in their favour. Moreover, of the 99, 56 have only one objector; and since a vote of 4 to 1 is as much as one could expect, we may count them also as approved, and are left with only 43; and, of this already vanishing figure, 29 have only two objectors. So that after all there is a majority of votes against only 14, and there is no instance of any one word which all five objectors oppose. So much for the bare numbers. We could have no plainer demonstration of the actual condition of these words in our speech.

We propose to deal separately with all the words that have a majority scored against the B.B.C. decision, and also with any others to which we think objections may be rightly sustained or which can be usefully examined, and we will take them in their alphabetical order; but before doing this, we shall separate off the French words that are scattered about the list, of which (counting a good many that invite no remark) there are some three dozen. This is a convenient plan, because these words, in so far as they have any claim to be called English, are all ruled, or should be ruled, by simple principles, which, though easy of demonstration, our folk are very slow to get hold of: and that is the reason why we have so often preached on this subject.[1]

Though all foreign words, *mutatis mutandis*, are subject to the same general principles, we shall deal here only with the French problem. A French word does not become English until it has ceased to be French. A man, speaking or writing, is at liberty to introduce a French word when-

[1] References are Tract III, pp. 10 and foll.; V, pp. 3–21; XIII, p. 34.

ever he chooses, and he may be tempted to do so for lack of an English word which exactly suits his shade of meaning; just as Cicero was compelled to write Greek words in his philosophical treatises. When such French words are used in literature, they are printed in italics with their foreign accents, as Greek words would be, and however well we may be accustomed to them they are French words and not English: an Englishman, who does not know any French, cannot read them at all, and if they make their way into the rub of common speech, they will be spoken with some attempt at French pronunciation, which in the mouths that make and rule our English will always be a sound that can be spelt in English, as no French word can be.

Words in this condition are truly *French words mispronounced*: and if the mispronunciation should settle down and the French word be retained in this hybrid and usually disagreeable form, it will in time come to be spelt with the English letters that phonetically represent the English mispronunciation: *ennui* will become *onwee*.

If this be not done—if the word retain its French spelling and be left to be pronounced as best it can, its fate, if it comes into general use, will be determined by the eye—it will be pronounced as if it were an English word: thus if popular tea-shops paint their title of CAFE over their doors the word will be pronounced like *chafe* and *safe*; and that would be as good an English word as *quixotic*.

If a French word has to be imported and domiciled with us, there is only one course open, and that is boldly to transfigure it, in the manner whereby a very large proportion of our speech has won its harmony and national character: and we need to lose or forgo our squeamishness in the process, for you cannot make an omelet without breaking of eggs.

The French words which have lately come or are now coming into our speech are in all stages of self-consciousness and incompetent disorder, and the examples we have here will amply serve to illustrate the situation. It must be remembered that the objectionable recommendations of the B.B.C. Committee do not represent their opinion as to how these words *ought* to be treated, but only how the Announcer *had better pronounce them* if he would avoid criticism or ridicule; which he can best ensure by using the most widely recognized form of the particular transi-

tional stage which they are supposed to have reached. As these considerations are outside the interests of the S.P.E., we shall neglect them, and treat each word on its own merits.

FRENCH WORDS

ENVELOPE. [B.B.C. 1st syllable *énn-* not *on-*.]

This is a good example of a word holding on desperately to the last vestiges of its French self-consciousness; for one of our critics still adheres to the form which we can only write in English as *onvelope*.

But has any one ever said that he was 'onveloped in a cloud of dust'? Shakespeare (and others) had already written *invelop'd*, and most people probably now speak *in-* and not *en-* in the verb where the syllable is unaccented. But in the substantive where it is accented it can keep its *en-*. [B.B.C. confirmed.]

ENTOURAGE. [B.B.C. *ontoordáazh.*]

This word, on the other hand, is an extreme example of obstinate refusal to take English pronunciation, probably because it is still confined to literary use. Whence the B.B.C. advise 'ontooráazh', which is intended to be the nearest approach to French pronunciation that can be expected. Only one of our critics objects to this, and his objection is that it is not sufficiently French. He would have it as a pure French word, while all the others pass it as 'French mispronounced'.

The introduction of the word is attributed in the O.E.D. to De Quincey, who italicized it; but Thackeray dropped the italics, and if it had not remained a literary word it would long ago have become English, for there is nothing to forbid its being received as such. Has any one still any lurking French consciousness in speaking of *courage*? *Entourage* offers no difficulty. The root-syllable *tour* is very common in English in its proper connotation and ensures the accentuation. The only question is whether we should speak it and write it *entourage*, or *intourage*. [B.B.C. disapproved.]

EN- or IN-.

The question whether these words should have IN- or EN- as their prefix is very complicated: there is full historical

information as to actual practice in the O.E.D. under the headings of these prefixes.

The main points are these:

1st. That EN- was the French form of the Latin preposition IN-, so that our English words which were borrowed from the French inherited EN-; whereas words taken directly from the Latin inherited IN-; but since these French words were mostly known to us also in their Latin form there was not strict observance of this rule.

2nd. There is no doubt that when this EN- prefix is unaccented, it has a tendency in our speech to take the lighter form IN-, however it is written; and, nowadays, those who would scrupulously write EN- will often unconsciously speak IN- in the same word.

Hence some of our phonetic lawgivers and prophets conclude that IN- is the *natural* English form, which is crying to assert itself and must eventually prevail in all cases. On the other hand, it may be argued that, since this is an unintentional slovenry, it should be resisted; because it tends to assimilate words, whereas the perfecting of speech lies in their differentiation: there can be no fear of our not having enough careless forms.

3rd. EN- has an undeniable claim to protection, because the Latin prefix IN- is ambiguous, having two distinct significations: it represents not only their preposition IN-, but (from a separate origin) it is the common *negative* prefix to adjectives: and it has thus come into English also as our usual negative prefix not only for words of Latin or Romanic origin as *inability*, *incautious*, *inconceivable*, *indistinguishable*, but is freely used, even when no corresponding formation exists in Latin. This ambiguity is seen in *incorporate*, *incorporeal*, in which the meaning of the prefix is absolutely different in the two words; and such inconvenience is often obviated for us by substituting the old English negative UN-.

Some words have taken both forms, as *undistinguishable* and *indistinguishable*; *unavailable* and *inavailable*—and though we keep *inability* we prefer *unable* and rightly distinguish *enable*.

The general French rule, Littré says, was to distinguish these prefixes, using EN- for the preposition IN-, and IN- for the negative; yet French practice shows exceptions to both uses; for their verbs *imbiber*, *imposer*, *illuminer* have the EN- signification; whereas on the other hand EN- has

the negative value in *ennemie* and *envie*, which are the Latin *inimicus* and *invidia*; but since the prefix in these words is strongly accented by us, it sounds like the root, and its humble negative origin being entirely lost causes us no ambiguity.

This ambiguity of a constantly recurring prefix is no doubt a blot in our speech; because however we may be accustomed to it, it will often imperceptibly be weakening the force of a word: indeed in a well-composed sentence the occurrence of the prefix in one sense may even forbid the use of some other appropriate word whose similar prefix happens to have the other meaning. Pairs like *incorporate* and *incorporeal*, *impersonate* and *impersonal* cannot escape notice, but you could not, for instance, well describe a quality as being *incorporate* and *inseparable*.

Now since the forms *encorporate* and *empersonate* would plainly cure these particular pairs it follows that, since we cannot get rid of the indiscriminate use of the negative IN-, we should keep EN- in the sense of the Latin and English preposition wherever we are fortunate enough to have it: and that it would be wiser and better to seek to enforce and extend its use, rather than allow it to go on degrading; thus adding more and more to the confusion.

ENCLAVE. [B.B.C. *énklayv.*]

= *enclosure*: a variant derivative from Latin *claudere*, *clausis*: quoted by Littré from the fourteenth century in its special meaning of a territory enclosed by foreign territories. When adopted much later into English use, it demeaned itself with unusual propriety, and is already recognized with full English pronunciation in American and English dictionaries as the B.B.C. would have it. This is one of the words that have three objectors, who would restore the French pronunciation, apparently unaware of its unconditional submission.

[B.B.C. approved.]

ENNUI. [B.B.C. *ónwee.*]

This is an old customer, qui nous a donné beaucoup d'ennui. Why, after having been once Englished as *annoy*, should it come up again to claim a fresh admittance and new dress? In French, the word serves all purposes. Littré says of it, 'Dans le style relevé, ennui est un mot d'une grande force et qui s'applique à toutes sortes de

souffrances de l'âme: les ennuis du trône; des ennuis cuisants. Dans le langage ordinaire, il perd beaucoup de sa force et se borne à désigner ce qui fait paraître le temps long.' It came into English very early. Wycliffe has:

Mi soule nappide for anoye.

(This from the O.E.D., which records an early spelling, 'onnuy'.) At its re-entry, when Evelyn wrote in 1667, 'We have hardly any words which do fully express the French naiveté, ennui, bizarre', our English word 'bore' had not come into use: at least the O.E.D. gives no example till a century later, when, however, it appears to be quite common. An amusing quotation is: 1767 'I enclose you a packet of letters, which if they are French, the Lord deliver you from the bore'. The definition in the O.E.D. throws some light on the difficulty. 'The malady of "ennui" supposed to be specifically French, as the "spleen" was supposed to be English; a fit of ennui or sulks; a dull time.'

Mr. Fowler,[1] whose remarks on French words should be digested, recommends *ŏnwē*, as the B.B.C. do: but this does not look like an English word—and since *ennui* proper (allowing there to be such a thing, as distinguished from *boredom*, *annoy*, and *melancholy*) is still a privilege of the upper classes, we are inclined to agree with Lord Balfour, who would write it and speak it as a French word.

All our other critics approved ónwee except one, who preferred onwée.

[B.B.C. disapproved.]

ENSEMBLE. [B.B.C. *onsómble.*]

Of all their suggestions the B.B.C.'s *onsomble* shocks me the most. It is of course 'French mispronounced', yet it has only two objectors who both prefer a more foreign accent. I think I am right in saying that 100 years ago it was the fashion to speak all these French words Englishwise with an open British contempt for anything foreign; whereas now there is an opposite fashion of punctilious correctness. Neither of these fashions is right or tenable; the second is impossible and the first gives us such words as *onsomble.*

In all these three words it is the French nasal which is the main difficulty, for it is unknown in English. In the

[1] *Dictionary of English Usage*, p. 193.

O.E.D. the word *ensemble* is given as añsāñb'l, and one may judge, from the look of that, of what practical use it can be. We need this word, or something equivalent: we cannot make a substantive of our adverb *together* as the French have of their adverb *ensemble* (= Latin in-simul): it is as if we would not wrong the integrity of an adverb by making a substantive of it, and I share this feeling.

We must then either take *ensemble* and pronounce it as we do *assemble* (which we have learned not to call *assomble*), or we must find a substitute. At this moment the word *comport* occurs to me as an equivalent, which in any right context would ensure its signification.

There seems little hope of any one at present being bold enough to say *ensemble* as an English word, although we have *assemble*, or even to venture *ensemblage* like *assemblage*.

Talking with the musicians at the Royal College some years ago I won them over, as I thought, to the propriety of using the form *tamber* for *timbre* (as we have *chamber* for *chambre*, *camber* for *cambre*, &c.: and the *a* of *tamber* is justified by *tambour*, which is the same root; and *timber* being impossible).[1] They all recognized the French pronunciation to be a nuisance and agreed to adopt my solution; but when it came to making the venture, they all relapsed or funked, but Gustav Holst.

[B.B.C. disapproved.]

ENVIRONS. [B.B.C. stress on second syll., vowel as *sigh*.]

Which is approved by all of our critics save one, who would keep French 'accent' in all French words.

[B.B.C. approved.]

FAUTEUIL. [B.B.C. *fōtill.*]

Fauteuil is the French form of our *faldstool* (= *folding stool*), a very old English word. The French is traced through the Low Latin from the High German. In modern French, *fauteuil* is really what we call an *arm-chair*; that is, a chair, not only with elbows, but with a back, and it has magnificent associations; for instance, a seat in the French Academy—a suggestion gratifying to the occupants of the more expensive seats in the theatre which we are accustomed to call *the stalls*.

And here there is a remarkable double coincidence; for,

[1] Tract III, p. 11.

though in our theatres these seats have their legs immovably fixed to the ground, they are true *faldstools* in this respect that their seats are hinged in the manner of the Misereres in the *stalls* of our cathedrals.

The French word *fauteuil*, as a term for theatre-stalls, came into popular recognition lately when it was adopted for the chief seats in the Cinemagogues: and as nobody wishes to call them *faldstools*, nor is likely to do so, we can find employment for the French word: but four out of five of our critics object to its being Englished, as proposed by the B.B.C. We expect that those who have to use the word will be glad of a recognized English form.

The simplest kind of folding stool is what we now call a *campstool*. The better sort which date from Rome and Greece were made with curved legs and must very early have had elbows. It was a common shape for 'thrones' and chairs which did not fold.

There were used of course at all times all kinds of stools for all occasions and purposes, but in church and for special functions they were no doubt ornamental. The name remains in our church for the lectern from which the Litany is sometimes sung at the entrance to the choir. This use of the *faldstool* for a *lectern* probably arose from the practice of setting a faldstool in front of the Bishop for his convenience when he knelt.[1]

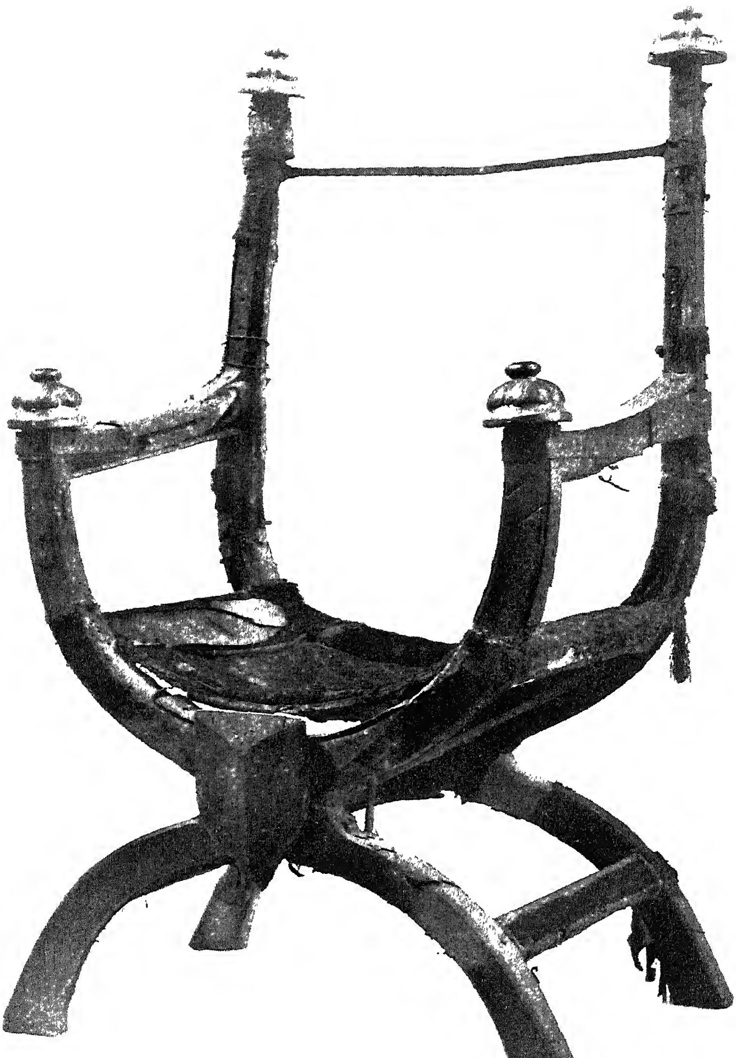
[B.B.C. approved.]

TRAIT. [B.B.C. *trayt.*]

This word, another form of *Tract* from Latin *trahere*, *tractus*, is an example of how simple roots diverge from a single primary meaning into innumerable specialized significations. Thus our verb *to draw*, equivalent to the Latin *trahere*, is defined in the O.E.D. under 70 heads and, with various prepositions, as many as 99. The advantage of a separate distinct form for any one specialized meaning is very great; as may be seen from Littré's dictionary, where *Trait* is described under 40 heads, whereas in our O.E.D. it is confined to 3 or 4 (excluding obsolete uses) which are all of allied meaning.

Granting then the need of the word in English, the

[1] The accompanying picture is from a fourteenth-century faldstool in York Minster, used last in the enthronement of Archbishop Temple. The beautiful frontispiece is from the early twelfth-century Vatican MS. Lat. 4939 containing Beneventan Annals, and shortly to be published in Dr. E. A. Lowe's *Scriptura Beneventana* (Oxford).



A FOURTEENTH-CENTURY FALDSTOOL

The enthronement chair in York Minster

question is how it should be pronounced. The following considerations will confirm the preference of the B.B.C. for *trait*: to quote again from the O.E.D.:

'The pronunciation tr$\bar{e}^{i}$ after modern French, in the nineteenth century considered in England the correct one, is becoming less general; in U.S. *trait* is the established one.'

Now in this the Americans are as usual more conservative than our modern speakers. Evidence for the old pronunciation may be seen in these spellings:

1545 without any further traite of tyme.
1561 and traitis of violet silk.
1601 a man may see what traicts and lineaments.

The modern French pronunciation, *tre·*, is a homophone with *tray*, an old English word of wide use, which resents invasion and can make it uncomfortable for the intruder. This is one of the 3/5 objectors and they are all in favour of the nineteenth-century Frenchification.

[B.B.C. approved.]

BRUIT. [B.B.C. *brute.*]

This word is a true homophone with *brute* and was not often distinguished in spelling. In the sixteenth century the two seem to have been on pretty equal terms: and *bruit* being a verb as well as substantive had some advantage. But *brute beast* with its offspring *brutal*, *brutish*, &c., became so strong that even the verb *to bruit* (as in 'bruited abroad') lost its hold: for though *bruited* had no actual ambiguity the sound *brute* had won such forceful suggestion that no alien connotation could pass undisturbed. Hence *bruited* is now seldom heard in speech and would seem in the last hundred years to have been dying out even from literature.

Bruited, with the *i* sounded as it is sometimes heard, is a spelling pronunciation, due to the speaker's fear of the homophone, and this, though *fruited*, *suited*, and *recruited* stand in the way, would seem to be the only chance the word has of escaping extinction: and to extinction we may leave it without regret, for it is of no use. Two objectors.

[B.B.C. approved.]

GARAGE. [B.B.C. *gárraazh.*]

The B.B.C. advise the French pronunciation; and it may have some short lease of life, because of the word

barrage from which it only differs by one letter; for although the O.E.D. 1885 gave the pronunciation of this as bārėdʒ; yet the French sound, which we cannot write (although we have it in Rajah), was usually maintained when the word came into the use of the British engineers, who were busied in damming the Nile more than fifty years ago. During the Great War the word came up afresh, with a new application in artillery, and again kept its French form, but there can be no doubt that, unless we can spell this sound, *barrage* will follow all the other *-ages*, and *garage* most likely has already done so, because it is spelt out at every street corner.

One can feel no sentiment about the pronunciation of *garage*, except to deplore that there should be another word added to the some 200 which used to be *-age* and are now commonly pronounced *-edge* or *-idge*; for instance, Jones records in his dictionary (1917) that cultivated Southern English people, in their ordinary conversation, pronounce *parsonage* as *pahsnidg* (pa:sn̩idʒ). Anything that can check the spread of this disease is useful, and it is to be hoped that the B.B.C. announcers will set the example of a more agreeable solution than the phoneticians have predetermined.

The sound in *Rajah* seems to me to be misrepresented by *dge*, the consonant being rather that in *azure* and *pleasure*, though Englishmen are inclined to put a *d* into it, as D. Jones represents them, for he spells *Rajah* and *large* with the same symbols a:dʒ: which one critic approves; there was no other objection to the B.B.C. recommendation.

[B.B.C. approved.]

Finally, the objection to French mispronounced does not apply to such terms as *chargé d'affaires*, *communiqué*, &c., which are of technical use and confined to circles in which knowledge of French is necessary and can be assumed. They may be considered as true French words to be pronounced as conveniently as may be, and they form a class that provides at least a temporary lodging for other French unassimilables.

WORDS OTHER THAN FRENCH

ACOUSTIC. [B.B.C. *acóostic.*]

The doubt is whether the second syllable should be pronounced as *cow* or as *coo*.

The history of *Acoustic* is that it is a learned semi-scientific word not earlier than the seventeenth century and it has never entered into common speech, and being a Greek word it took its authoritative pronunciation from classical scholars who were accustomed to pronounce the Greek word ἀκούω in their grammars with the *au* diphthong of *cow* and thus set the fashion: but since of late years our classical purists have changed their pronunciation of the Greek *ου* to *u* they are now themselves divided between the two opposed uses: and the reason why three of our five critics vote for *cow* is because they are of the age that imbibed the older tradition. But some of those who prefer *cow* would argue that the diphthong *ou* in English stands for this *au* sound, just as in French it stands for *u*, and the fact that scholars redd *au* in the *ou* of ἀκούω confirms their contention.[1]

Now the question of how these diphthongs or digraphs arose in our speech is too involved to have any practical bearing, but the actual signification that they have acquired is of practical import, and the advocates of *cow* may reasonably assert that most words in which it occurs in accented syllables are pronounced with the *au* diphthong: for instance, *house* and *mouse* (which the Germans write correctly *Haus* and *Maus*), *out*, *bout*, *scout*, *gout*, *shout*, *lout*, *clout*, *flout*, *pout*, *spout*, *mound*, *mouth*, *mount*, *noun*, &c., &c.; but though there may be more such monosyllabic examples of the *cow* sound than of the *coo*, yet in common talk the *coo* sound has overwhelming predominance, for *you* (*yū*) and *your* (*yūr*) are in every one's mouth at every moment and the shorter forms of *u* in *would*, *could*, and *should* are as frequent; moreover, there is a fair list of words that favour *coo*, such as *youth*, *uncouth*, *tour*, *pour*, *route*, *dour*, *bourn*, *ouzel*, and the river names of *Stour* and *Ouse*: then adopted French words as *douceur*, *oubliette*, *outrance* (not to speak of those many exceptions which count neither way, as *double*, *trouble*, *dough*, *enough*, *soul*, *course*, *source*, *court*, *brought*, *thought*, *fought*), and besides these, some fifty words like *honour* and *colour*, whose terminal syllable is written *ou* with pronunciation inclining to *u*, while some thousand words with the *-ous* suffix, as *dubious*, *tremendous*,

[1] Indeed it was by the abuse of this very diphthong *au* that schoolmasters, by inculcating phonetic nonsense, poisoned little boys' ears and made it impossible for them to make their first steps in philology: for, when they pronounced *vous*, the contraction of *voos*, as *vavs*, they did me more mischief than they could ever undo.

jealous, all absolutely repudiate any inclination to the *au* diphthong of *cow*; so here again there is nothing to overrule us in our decision.

Since common practice and phonetic propriety fail us, we may be allowed to consider the comparative agreeableness of the two sounds; that is, which of them makes the more pleasant word. Now those who have any feeling in this matter will all agree that *u* is a more pleasant sound than *au*: it is indeed the softest of all true Romance vowels and is preferable for its euphonic quality.

It was asserted in committee that scientists were almost all habituated to *coo*: on inquiry this turned out to be an exaggeration, because in Oxford and Cambridge, where Greek was still alive, both forms were in use among the scientists.

The O.E.D. puts *coo* in the first place and the American Webster and Century do the same. [B.B.C. approved.]

AERIAL. [B.B.C. noun *airial*; adjective *ay-éerial.*]

There are two objectors to the B.B.C. ruling, and both of them wish the two words to be pronounced alike; but one of them would have them one way, and the other, the other.

We will take the adjective first: it is a Latin word, very familiar to scholars and much used in poetry; though rarely, if ever, spoken; and from their familiarity with its place in Latin verse, I should have thought that the poets must have pronounced it with a short *ĕ—ey-ĕrrial.* I have always done so, and thus Gerard Hopkins rhymes it:

> And flock-bells of the aerial
> Down's forefalls beat to the burial.
>
> *Euryd.* l. 8.

And this pronunciation seems necessary in Latin:

> ipse locum, aeriae quo congessere palumbes.
> Protenus aërii mellis caelestia dona.

But the O.E.D., though it recognizes this pronunciation, says the long *ē* is more common, and Webster knows only the long *ē*; and as none of our critics oppose it, we must conclude that this long *ē* [*ī*] is the usual pronunciation (compare *funereal*).

As for the noun, since our common pronunciation of the Latin *aer* is indistinguishable from our own *air*, we should expect that a word spelt *aerial* would, if offered to the

public, be pronounced by them as we pronounce *Ariel*, and this appears to be what has happened in England since the 'wireless' inventions: there is no objection to it.

The deduction from these actual conditions seems to be that the adjective must henceforth have two forms: 1st, the old and longer 'Latin' form which has three full places in Shelley's syllabic verse, e.g.

> Stand ever mantling with aëreal dew.
>
> *Prom.* III. iii. 143.

and 2nd, the new shorter form *airial* = 'wireless'. This being an adjective used for a noun is, and will be, as much one as the other. It will certainly be far more widely known than the old form and, unless it be differently spelt, will be misredd into the older poets: e.g. Shelley's line

> Prone and | the' aë|real ice | clings o-|ver it
>
> *Prom.* III. ii. 17.

will be redd

> Prone and | the ai-|rial ice |

[B.B.C. approved.]

[M. BARNES.]

†**ALLIES.** [B.B.C. stress on 2nd syllable.] 3 objectors.

This and all the other words noted with the large dagger were selected for full treatment, but the scholar who had undertaken to deal with them was attacked by influenza and incapacitated for so long that we had to go to press without his contribution. I shall therefore only record here how the B.B.C.'s advice fared with our five critics. The words may be discussed later if the subject and our way of handling it prove acceptable to our readers.

†**APPARENT.** [B.B.C. *appárrent.*]
3 objectors.

†**BADE.** [B.B.C. *bad.*]
2 objectors—Lord Grey and Lord Balfour.

†**BEDIZEN.** [B.B.C. rhymes with horizon.]
2 objectors.

†**COGNISANT.** [B.B.C. *cógnizzant.*]
1 objector.

COMPARABLE. See *Disputable.*

†**CONSTRUE.** [B.B.C. stress on 2nd syllable.]
2 objectors.

CONTEMPLATIVE. [B.B.C. *cóntemplaytiv.*]

The objectors divide very unexpectedly on this word. The question is of course merely one of accent. The word *contemplation* had never any variant form and Shakespeare has the verb *cóntemplate*:

So many hours must I cóntemplate.
3 *Henry VI*, II. v. 33.

but the earlier accent was *contémplate*, and hence all the quadrisyllabic forms of the verb and *contémplative* for a long while kept this accent. So Shakespeare has

Still and contémplative in living art.
L. L. L. I. i. 14.

Shelley would actually conjugate the verb thus:

I cóntemplate,
Thou contémplatest, &c.
Methinks I grow like what I cóntemplate.
Prom. I. 450.
Thou art as God whom thou contémplatest.
Hellas, 761.

And thus Wordsworth:

For feeling and contémplative regard.

Contémplative is a poetic word and, never having suffered the rub of common talk, is with its old-fashioned accent so strongly entrenched in poetry that it would hold its own, if it were not for the fact that *cóntempláted* is quite a common word, as when we say 'This or that was never cóntempláted'. So that if *contemplative* is to come into talk, it must follow the more modern accent, though it is likely to keep its old form in our poetry.

It is rather strange that of our five critics the three elders approve the more modern use, the two younger object to it and would hold on to the poetic form.

Fowler in his *Usage* brackets *contemplate* with *compensate*.
[B.B.C. approved.]

CONTUMELY. [B.B.C. *contéwmĕly.*]

This is a four-syllable word, which in the English and American dictionaries is accented on the first syllable. In the American dictionaries the penultimate *e* is marked long,

though unaccented. The famous authority for this word is the line in *Hamlet*, III. i. 71:

> The oppressor's wrong, the proud man's contumely,

which I read as the American dictionary preserves tradition. The value of the penultimate was probably stabilized by the adjective *contumelious*,

> Of contumelious, beastly, mad-brain'd war.
>
> *Timon*, V. i. 177.

But that this tradition was lost in England would appear when Hood could write:

> Perishing gloomily
> Spurr'd by contumely.

And Mr. Fowler[1] says that there are five possible pronunciations, and at that he omits the American one, and prophesies that the penultimate vowel is doomed, because a 'stressed syllable followed by three unstressed ones is very unpopular except with professors and the like', whence it would seem that the word can only keep its penultimate syllable by moving its accent, as was certainly done by Hood and may be supposed to have been received in his time, and at any rate his popular poem must have had a great influence, though Walker in 1824 accents the quadrisyllable on the first.

Mr. Fowler's prize-holder *cóntumly* sounds to me like an adverb of obscure signification. Shakespeare's line is no authority for it, or even for the suggestion of it.

[Two of our five critics object, and we agree with them.]

DISPUTABLE AND INDISPUTABLE. [B.B.C. *dispútable.*]

About the position of accent: common use is divided. The majority is plainly for *dísputable.*

There are a great number of disyllabic verbs, accented on the last like *ascribe*, *avoid*, *inform*. How it comes that there are so many in opposition to the general Teutonic rule of accenting the first syllable, is due to the rule that *compounds consisting of particles (whether separable or unseparable) and verbs, had their stress on the verb*,[2] and it is

[1] *Dictionary of Modern Usage.*

[2] (Morris, *Historical Outlines of English Accidence*, § 66), and this is the account of disyllabic verbs having a final accent while their identical substantives are accented on the first syllable. And this habit extended itself to other words than those which it originally affected.

a general rule that such words taking the suffix *able* retain their original accent.

We must therefore ask what exceptions there are and whether *dispute* is an exception.

Typical exceptions are *admirable*, *lamentable*, *comparable*, and what is common to these words is that the root- or verb-syllable in them is not recognizable as an English word: *mire*, *ment*, *pare*, are not syllables with any appropriate meaning; and this condition, which lightens the syllable, allows and even invites loss and recession of accent.

It is not a rule that words in this condition will recess their accent: there are too many examples on the other side; but it is the condition which has provoked recession in the words which have yielded to it. Now *pute* and *fute* are no more significant than *mire* and *ment*, and as we have got *réputable* and *réfutable*, it is natural that *confutable*, *disputable*, *computable*, and *imputable* should go with them.

The B.B.C.'s pronouncement in favour of *dispútable* testifies to a present tendency to ignore tradition in favour of what seems to be a general rule and common-sense. And that this is recent is shown by the fact that it is the two younger of our five critics who pass *dispútable*, while the three older speakers object, and we concur in their objection.

[B.B.C. disapproved.]

DOCILE. [B.B.C. *dosyle.*] See *Fragile.*

[B.B.C. disapproved.]

DOCTRINAL. [B.B.C. *Doctrýnal.*]

All our five critics approve of the B.B.C. ruling, and the pronunciation *doctrīnal* has been prevalent for so long that most people will wonder at its being questioned at all. But its being among the doubtful words proves that the old English *dóctrinal*, which is quite in order, is still heard, and in Walker's dictionary (1824) it still survived as correct: (moreover, everybody says *doctrin'* and *endóctrinate*: and we have also *dóctorate* and *dóctoral*) and this in spite of Johnson's dictionary, which, it would seem, must have had great force in establishing the later pronunciation. His entry is simply as follows:

DOCTRI'NAL. *adj.* [*doctrina.* Latin].

The entry in O.E.D. is:

DOCTRINAL (dǫ·ktrinăl, dǫktrəi·năl), *a.* and *sb.* [The sb. was a.

F. *doctrinal* (13th c. in Littré); the adj. was perh. more directly ad. late L. *doctrīnāl-is* (Isidore), f. *doctrīna* learning, doctrine: see -AL.

The historical pronunciation, from L. *doctrīnā·lis*, Fr. and ME. *doctrina·l*, is *do·ctrinal* (so Bailey, Todd); *doctrī·nal* (J.) passes over the actual L., Fr., and ME. words, to reach the ulterior *doctrīna*.][1]

The word is not a likely one to find in verse, but Johnson must have known *Hudibras*:

> Or any Opinion true or false
> Declar'd as such, in Doctrinals.
> Part III, canto 2, ll. 615–16.

Dr. Johnson's predilection for latinized forms is notorious, but how far it could pervert his equally notorious common-sense is not sufficiently recognized.[2] This may be amply exposed in his treatment of the word *medicinal*, which we shall here examine:

If any one were asked nowadays how the word *medicinal* is pronounced, he would say that it was a four-syllable word accented preferably on the short second syllable (*medíssinal*), but sometimes on the lengthened penultimate (*medisáinal*). He would be probably unaware that both these pronunciations are recent, and that until about Dr. Johnson's time (an approximate date subject to correction) the word had long been a trisyllable with the accent on the first (*méd'sinal*). The substantive *medicine* had fixed itself in common speech very early as a disyllable, as Butler humorously rhymed it in *Hudibras*:

> Tho' stor'd with Deletery Med'cines
> (Which whosoever took is dead since);
> I. ii. 317.

and it ruled all its derivatives, *med'cinal, med'cinally, med'cinable*, as will amply appear.

This condition of the substantive was fully recognized by Dr. Johnson, but his treatment of the derivatives is peculiar. His great dictionary appeared in 1755. I am using a copy

[1] It is noteworthy that Webster seems to imagine that the prevalent English *doctrínal* must be older than the American *dóctrinal*: whereas the truth is that they have escaped our corruption. Nor is this a solitary example.

[2] Boswell's book is good enough, but I have wished that Charles Lamb could sometimes have been present when the elephant was trampling on the crawfish.

of the second issue, 1756. The entry under *medicinal* is as follows:

MEDICI'NAL, *adj.* [*medicinalis*, Latin: this word is now commonly pronounced *medícinal*, with the accent on the second syllable; but more properly, and more agreeably to the best authorities, *medici'nal.*]

He then proceeds to give quotations from his 'best authorities'. These I transcribe as he prints them and I shall number them for convenience:

(1) Come with words as *medicinal* as true.
Shakespeare.

But in Shakespeare the whole line is:

Do come with words as medicinal as true.
Winter's Tale, II. iii. 37.

and it is unfortunate that in illustrating the meaning of the word he should have forgotten his engagement on the pronunciation; for the omission of the first syllable in a blank verse must occasion confusion: one cannot guess how Johnson redd it. The full text implies *med'cinal*, which agrees with neither of his pronunciations.

(2) Thoughts my tormentors arm'd with deadly stings,
Mangle my apprehensive tenderest parts;
Exasperate, exulcerate and raise
Dire inflammation, which no cooling herb
Nor *medicinal* liquor can assuage. *Milton.*

This last line is printed by Milton:

Or medcinal liquor can asswage. *Samson*, 627.

The Johnsonian quotation, however, makes it seem a passage from the blank verse, whereas it is actually an eight-syllable line from a lyric chorus; and if he had quoted the two lines that follow, instead of the four that precede the *medcinal* line, the irregularity of the metre would have been obvious.

(3) The second causes took the swift command,
The *medicinal* head, the ready hand;
All but eternal doom was conquer'd by their art.
Dryden.

The misfortune in this quotation is of the same kind as the last, but it is worse. This also is quoted as if it was a regular decasyllabic verse, but, like the last, it is from an

irregular ode; and he again misrepresents the text, for Dryden printed

> The second Causes took the swift Command,
> The med'cinal Head, the ready Hand,
> All eager to perform their Part,
> All but Eternal Doom was conquer'd by their Art.
> *Thren. Aug.* 110.

Now here he has not only altered the author's spelling, but has actually omitted (without notice) the tell-tale eight-syllable rhyme-line, which would have exposed his error; and if he had wanted a real ten-syllable line, he might have found it in the same poem:

> With all the cannon of the med'cinal war. 170.

(4) Learn'd he was in *med'cinal* lore,
For by his side a pouch he wore. BUTLER.

But here again he alters the text: at least in my old copy of *Hudibras* I read:

> Learned he was in Med'c'nal lore. II. i. 223.

From this quotation we learn that Johnson not only invented a four-syllable *medicīnal* for his best authorities, but also a trisyllable *med'cīnal*, which he must have misredd into Milton:

> And yet more med'cinal is it than that Moly
> That Hermes once to wise Ulysses gave.
> *Com.* 636.

But what could he have made of Donne?

> Since herbes, and roots, by dying lose not all,
> But they, yea Ashes too, are medicinall.
> *An. Anatomy: First ann.* 403.

Or again

> If by the way to him befall
> Some odoriferous thing, or medicinall.
> *Love's Alch.* 9.

The adverb is illustrated as follows:

'MEDICI'NALLY, *adv.*
(5) The witnesses that leech-like liv'd on blood,
Sucking for them were *med'cinally* good. *Dryden.*'

This is correctly quoted and it confirms our last surmise.

Finally there remains *Medicinable*, for which the entry is thus:

'MEDI'CINABLE. *adj.* [*medicinalis*, Lat.] Having the power of physick.'

and by physick he means medicine: and the three quotations confirm his correct definition, but as they are all from prose writers they are no guide to pronunciation.

First, concerning the meaning of the word.

This is one of the words in which the suffix -able has not its simplest and commonest and most grammatical sense, as in *breakable*, i.e. that which can be broken. The various uses to which this suffix has been adapted are exhaustively treated by H. W. Fowler, in his *Mod. Eng. Usage*, which is in the hands of all our members; and we assume their knowledge of the general facts.

So long as an -able word, which has not this simple sense, is in common use, as *medicinable* appears to have been in Shakespeare's time, it causes no inconvenience—the word *serviceable* gives us no difficulty; but if it falls out of common use, it is confusing, as can easily be shown. Anybody nowadays reading Shakespeare's

Some griefs are medicinable
Cym. III. ii. 32.

would suppose that it meant that some griefs were curable; but it does not mean this, it means some griefs are curative; that is, 'have a power' similar to medicine, as Johnson rightly defines the word.

The word occurs in three other places in Shakespeare, besides the one quoted above. They are as follows:

And therefore is the glorious planet Sol
In noble eminence enthroned and sphered
Amidst the other; whose medicinable eye
Corrects the ill aspects of planets evil.
Troilus, I. iii. 91.

Any impediment would be medicinable to me: I am sick in displeasure to him. *Ado*, II. ii. 5 (prose).

Then must you speake,
Of one that lou'd not wisely, but too well:
Of one, not easily Iealious, but being wrought,
Perplexed in the extreame: Of one, whose hand
(Like the base Iudean) threw a Pearle away
Richer then all his Tribe; Of one, whose subdu'd Eyes,
Albeit vn-vsed to the melting moode,
Drop teares as fast as the Arabian Trees
Their Medicinable gumme. Set you downe this:
And say besides . . . &c. *Othello*, ad fin.

These all show *medicinable* used in figurative and poetic sense.

But Johnson, who in his edition of *Shakespeare* 1765, printed *med'cinable* in *Troilus*, finding *medicinal* in the quarto of *Othello* preferred it to the *medicinable* of the Folio in this place, and in his text the line runs

Their medicinal gum. Set you down this

but that would have been an eight-syllable line (as the first four of his own quotations above show) and a bad one at that; while what is needed is the full sustention of the rhythm as it is preserved in the undoubtedly correct reading of the Folio; to which Steevens at once reverted without remark. But I suppose that it was due to Johnson that *medicinal* in this place, which can only be redd with Johnson's bogus pronunciation, blots the scholarship of the Globe edition, and I suppose also of others, for instance the 'Arden Shakespeare'. And thus Webster was deluded into asserting that *medicínal* occurs in Shakespeare.

Now if Johnson, as it would appear, thought that *medicinal* and *medicinable* were true synonyms, equivalent in meaning, we can understand that he may even have disliked the word *medicinable* and have wished to get rid of it; especially as its grammatical form was irregular and he did not know how to pronounce it. But the two words are not purely equivalent; it is plain that what is actually used in medicine and what might be used are not quite the same: and in the figurative use that Shakespeare makes of *med'cinable* this difference is of extreme poetic importance. The terrible exalted and condensed pathos of Othello's last speech, by the magic of which Shakespeare has wound up the intolerable torture of his tragedy in an overwhelming flood of compassion, cannot be analysed, but though its figures are missed or misinterpreted, those whom it masters do not imagine that Othello thought his tears would cure him or that the poet is holding the audience spell-bound by an apt allusion to the dispensary.

This examination of *medicinal* has led us rather far afield, but it illustrates in a remarkable manner the difficulty of deciding how any word should be pronounced.

(1) We see that the second vowel in *medicine* after having been entirely elided has been not only restored to its place, but has appropriated the verbal accent to itself in *medícinal*.

(2) That a word that was thoroughly Englished and domiciled has been throwing off its dress and reverting to

its fourteenth-century condition, as it was in Chaucer; for (though I speak without book) I would confidently guess that in post-Victorian verse *medicine* is more often a trisyllable than a disyllable.

(3) The great power of fashion to override what phoneticians think the inevitable laws that govern the changes of our speech.

To return to *doctrine*, where we began.

Though Johnson was no more 'right' with his *doctrínal* than with his *medicínal*, it is clear that this pseudo-classic fashion of speech which was so active fifty years ago had started a century earlier. How it is still working may be seen by observing the transit of two or three other words; the following table will explain itself.

Johnson, 1755.	Walker, 1824.	Webster. Late 19th century.	O.E.D.	Danl. Jones, 1917–.
Márital	Márital	Márital	Márital	1. Marítal 2. Márital
Cérvical	Cérvical	Cérvical	1. Cérvical 2. Cervícal	1. Cérvical 2. Cervícal
—	—	Ánthropoid	1. Ánthropoid 2. Anthrópoid	1. Ánthropoid 2. Anthrópoid
—	—	1. Décanal 2. Decánal	Decánal	Decánal
Intéstinal	Intéstinal	Intéstinal and B.B.C., 1928, Intestínal	Intéstinal	Intéstinal

The true English practice in the matter of words from the Latin is thoroughly dealt with in our Tract IV (for special notice of *doctrinal*, see p. 21), and all the authorities are in consensus: sceptics may refer to the *Oxford Dictionary* or to Mr. Fowler's *Usage*.

[B.B.C. and all our five critics disapproved.]

Ἰώνσων μέν νυν καὶ τὰ ἰητρικὰ ἔπεα χαιρέτω.

DYNAST. [B.B.C. *Dínnast.*]

B.B.C. rules *Dy̆nast* (*Dinnast*), to which the only objector is Lord Balfour—and there is something to be said for *Dȳnast*, though not for *Dȳnasty*. The word was specially treated in Tract IV, p. 26, by John Sargeaunt who rules for *Dy̆nast*, and thinks that the long *ȳ* is due to the inveterate notion that the letter *y* represents the sound by which that letter is called; and there is an amusing confirmation of this in the spontaneous pronunciation of *Ypres* during the War as *Wīpers*, by soldiers who did not know

that they were doing exactly as their ancestors had done 500 years earlier—for the Wypers Tower at Rye took its name from Lord Ypres.

English use tends to confirm Sargeaunt's ruling of *dȳnast*, but as this pronunciation rests on a Greek tradition and on the influence of Greek scholars, it has little chance of maintaining exception against our almost universal Latin habit, the rule for which would be that the disyllable is *dȳnast* and the trisyllable *dy̆nasty*, like *tȳrant* and *ty̆ranny*, also Greek words.

It appears from the dictionaries to be assumed that the disyllable and the trisyllable must keep the same vowel, which in English is usually short and in American usually long: the long vowel is generally attributed to the accepted pronunciation of compounds of this Greek root, *dynamics*, *dynamite*, &c., which arose and came into frequent use in the nineteenth century. [B.B.C. approved.]

ELEEMOSYNARY. [B.B.C. *ellimmóssinnary*.]

One of our critics prefers the *s* to be voiced, as I think I have been accustomed to hear it, but it has no authority that I have found in any dictionary, American or English, until Daniel Jones, who gives *mŏzi* as a second pronunciation.

EMACIATE. [B.B.C. *emmdyshiayt*.]

One of our critics objects that the doubled *m*, which is used in the B.B.C. ruling to indicate that the preceding *e* is short, misrepresents the syllable, which should be written *ĕ-mdciate*, not *em-mdciate*: on this point all the authorities are agreed, and the O.E.D. describes this *e* as the same as the *e* in *re-act*.

EPHEMERAL. [B.B.C. *efféinmeral*.]

One critic objects to the second *e* being ruled short. The word does not often come into talk, and *ephēmeral*, favoured probably by Greek scholars, has the authority of Sheridan (1780), but it is unnoticed in the O.E.D., and American dictionaries. [B.B.C. approved.]

EVIL. [B.B.C. *eev'l*.]

The loss of the last vowel in ordinary talk seems to be a fact: for only one of our critics objects: *ev'l* is recognized by the O.E.D. (1894) and Vizetelly reports for

America 'the *i* has reached the vanishing point'. D. Jones, however, gives *i:vil* as a secondary pronunciation: and since the word is treated as a disyllable in our poetry, it seems to us that the full pronunciation will persist in all careful speech. [B.B.C. disapproved.]

EYRIE. [B.B.C. 'rhymes with *sigh*'.]

The question is whether *eyr-* should be pronounced (1) as in *ire*, or (2) as in *ear*, or (3) as in *air*. The spelling *eyrie*, though it has the authority of Milton (*Paradise Lost*, vii. 424), is due to an erroneous derivation from *ey*, the native English form of *egg*; and good dictionaries (e.g. Oxford and Webster's New International) prefer the spelling *aerie*, which has an un-English look. The word in the senses 'nest of a bird (of prey)' and 'brood' appears in English in the sixteenth century as a borrowing from late Latin *aeria*, *area*, &c., 'nest', itself a learned form of Old French *aire* with the same sense. Old French *aire* seems to be derived from a special sense of Latin *ager* 'field', 'patch of ground'; and it had previously been received into Middle English as *aire*.

The word was not spoken often enough to secure the establishment and the handing down of a uniform English pronunciation. The pronunciation of the first syllable as in *ire* seems to be recent, and can be no more than a guess at an unfamiliar word. The pronunciation as in *ear* is older and is recognized by the best dictionaries, but probably has the same origin. The true pronunciation is as in *air*. This also is recognized by the best dictionaries, and is to be preferred. In the First Folio of Shakespeare, 1623, the word is spelt *ayerie*, *Richard the Third*, I. iii. 270; *ayery*, ibid.; *ayrie*, *Hamlet*, II. ii. 362; all of which might represent the adjective *airy*. The old homophony between the noun and the unrelated adjective is not a serious objection, because the words are not likely to be confused; though a superficial ambiguity appears in Shakespeare, *King John*, V. ii. 149:

> And like an Eagle, o're his ayerie towres, &c.

[B.B.C. disapproved.] [K. S.]

FANATIC. [B.B.C. *fanáttic*.]

This has two objectors but is well sustained; see Tract IV, p. 23, and add these examples.

> But tho' you cannot *Love*, you say,
> Out of your own *Fanatick* way.
> *Hud.* II. i. 331.
>
> But tho' no Pow'r of Heav'n or Hell
> Can pacify fanatick Zeal. III. ii. 713.

[B.B.C. approved.]

†FETID. [B.B.C. *féttid.*]
2 objectors.

† FETISH. [B.B.C. *féetish.*]
3 objectors.

FRAGILE. [B.B.C. *fráj-ill.*]

This spelling *frajill* should have had either a doubled *j*, or a short mark over the *a*. It is only the second syllable that is in question.

Against the B.B.C. ruling of *fragĭle* there are two objectors. Their objection, though untenable, has support in tradition, as appears in John Sargeaunt's notice of these words: this we will here quote from Tract IV, to save trouble of reference.

> Latin stems in **-ĭli**. These seem originally to have retained the short *i*. Thus Milton's spelling is 'facil' and 'fertil', while other seventeenth-century writers give 'steril'. This pronunciation still obtains in America, but in England the words seem to have been usually assimilated to 'fragile', as Milton spells it, which perhaps always [? commonly] lengthened the vowel. The penultimate vowel is short.

Of these words, which we spell with the suffix *ile*, some of them are from the Latin stem *ĭli*, and some from *īli*, and since the final *e* in the English word is always mute, and can have no other use except to lengthen the preceding vowel, it would seem reasonable that, instead of using it to ensure confusion, we should make it serve its only purpose, as Milton would have done, omitting it after the short *ĭl*, and keeping it to distinguish the long *īl*. Thus we should write *agil*, *facil*, *fertil*, *fossil*, *fragil*, *steril*, but *senile*, *juvenile*, *puerile*, *virile*, &c. Although our established pronunciation would forbid absolute conformity with the Latin in all the words, this use of the mute *e* would distinguish many correctly, while words which in English do not conform to the Latin quantity would have their exceptional pronunciation determined.

These convenient *il* spellings would not be new in English orthography, nor would the pronunciation in any case be a novelty. Milton's spelling has been noticed and all the six *il* words given above have often appeared in English literature without the mute *e*. In America the short *ĭl* pronunciation in the *ĭli* words is universal; and thus they keep the pronunciation *dossil* for *dōcīle*: *dŏcil* is recognized as a secondary pronunciation in the O.E.D. I have myself inherited it and regard *dōcīle* as an abomination, though the B.B.C. recommend it and it has no objectors. And thus the Americans say *fútil*, where we say *fútile*; the long *u* is in order: see Tract IV, pp. 12 and 13, and p. 20, l. 16.

[B.B.C. approved.]

FURORE. [B.B.C. *Féwroar.*]

The question which the B.B.C. had to decide was whether the word *furore*, when it occurs in English literature, should be read as a word of two or three syllables. We have nothing to do with the *Con furore* which appears among other Italian words as a musical direction.

I remember how Heine in his *Pictures of Travel* writing, I think, from Lucca advises his readers to skip the ensuing chapter, because it will bore them, and regrets that he cannot do so himself. Such are my feelings now, and I shall write more at my ease if I think no one will read. I will do my best to state this involved business briefly. My exposition is merely a digest of what I have grabbed from Littré and the O.E.D.

We have two words in English, *fury* and *furor*: they are Latin words, from the French, and the French have them both, *furie* and *fureur*. Littré at the foot of *Fureur* has the following note:

-Syn. Fureur, Furie. Le radical de ces deux mots est le même; le suffixe seul est différent. Étymologiquement, la fureur est l'état d'un homme furieux; la Furie est un personnage mythologique chargé des vengeances des dieux. De là résulte que la fureur, bien que violente, peut être cachée dans le fond de l'âme, tandis que la furie éclate au dehors. Par une conséquence naturelle, furie a pu se dire de l'impétuosité d'une attaque, comme dans cette phrase consacrée: la furie française, qui exprime l'impétuosité des assaillants; tandis que fureur ne serait pas applicable et aurait un autre sens. D'autre part, il y a dans fureur une signification de folie, de transport qui n'est pas dans

furie; ce qui fait qu'on dit fureur prophétique, et non furie prophétique.

Now in English, though the Greek Erinyes are fully recognized, and *Fury* in the singular number can be used with that definite signification (and was by Milton transferred to the Fates, 'comes the blind Fury with the abhored shears'), yet it is our common word for impetuous passionate anger or rage (but note that *rage* itself is used sometimes in poetry for the poetic frenzy), and was never in English distinguished from *furor* in this personified or purely classical sense, and, since the sixteenth century *furor* has supplanted it, so that the distinction which Littré draws is impossible to us; and when writers wished to use the word in the sense of a craze or popular enthusiasm (as the French did in 'faire fureur, être fort en vogue, c'est une fureur') they found it pre-engaged with a much weightier association and therefore it was, I suppose, that Carlyle, though he could write in the *French Revolution*, 'Rises into furor almost Pythic', twenty-four years afterwards wrote, 'this blockhead is making quite a furore at Glasgow'.

This word then is like our troublesome *ennui*, for which, having dealt with it once satisfactorily, we are now asked to provide a new dress. Like *ennui* there is no simple solution: if we only add an *e* to it, that *e* will remain mute, and in speech there will be no distinction: if we are to make a new word it must be a trisyllable and spelt so as to ensure that pronunciation. It appears to us that *craze*, which seems to have specialized itself in the nineteenth century, is a useful word; and *rage*, quoted as early as 1725,

> The favorite phrases . . . the Rage, the Thing, the Twaddle and the Bore,

is a rival competitor for some senses: and as the word *frenzy* covers definite ground, we have really no need to make fresh terms with this old alien.

The B.B.C.'s phonetic spelling seems wrong: *furor* or *furore* is syllabized not as *pew-rents*, but like *four-oar*.

GEYSER. [B.B.C. *géezer*.]

The problem is like that of Eyrie (q.v.): should we pronounce the first syllable (1) as in *grey*, or (2) as in *eye*, or (3) as in *key*? And the reason for the doubt is the same:

there was seldom occasion to speak of a natural geyser, and therefore no traditional pronunciation could be established.

The nearest natural geysers to England are those of Iceland, and the word was borrowed in the latter part of the eighteenth century, when a new literary and political interest caused Dr. Johnson to plan a voyage to Iceland, and the Cabinet to consider its annexation. *Geysir*, derived from Icelandic *geysa*, 'to gush', is not a generic name, but the proper name of a notable intermittent fountain in Haukadal, near Mt. Hecla, which then threw up a column of water about 100 ft. high, affording a grand spectacle for visitors. It was later called the Great Geyser for distinction. There are good drawings of it by John Cleveley, who visited Iceland with Sir Joseph Banks in 1772, in British Museum Additional MS. 15511.—See *Islandica*, vol. xviii (1928).

The proper name was extended to gushing springs of the same kind, and whether because it was made known throughout Europe by von Troil's popular account of Iceland, or because of England's lead in geological discovery, it became established in the generalized sense in other languages: French *geyser*, German *geiser*, &c.

(1) The pronunciation as in *grey* is the oldest. It fairly represents the Icelandic sound, and is recognized by the best dictionaries.

(2) Natural geysers are found in two English-speaking countries—at Yellowstone Park in the United States and the Hot Lakes district of New Zealand. In both these countries the common pronunciation is as in *eye*, and this also is recognized by the best dictionaries. In its origin it is probably a learned guess at a foreign word, made on the assumption that the sound of *ey* would be the same as that of German *ey*, *ei*.

(3) Towards the end of the nineteenth century the mechanical device for heating bath-water made *geyser* a household word, and though the introducers gave it the vowel of *grey*, the pronunciation as in *key* gained ground. It has no roots in the past and is not mentioned by the Oxford Dictionary or the Century, while Webster's New International says it is 'no longer recognized'.

If there should be any connexion between the sound of a word and the thing it represents, then the wheezing noise of *geezer* does not do justice to the majesty of a natural

geyser, however appropriate it may be to the petty tyrant of the bathroom; and as this pronunciation is still further disadvantaged by the homophone *geezer* 'an old man or woman', we cannot commend it. The pronunciation as in *grey* is now rare, though it can claim historical correctness. The pronunciation as in *eye*, which has respectable authority, may well be preferred in order to keep English pronunciation in line with American and Colonial wherever there is a reasonable choice.

The Icelandic name *Geysir* is pronounced with *s*, not with *z*; and accordingly forms (1) and (2) are found both with *s* and *z* in the dictionaries. But *s* in such a position can hardly be preserved against the weight of English usage, and we may accept the pronunciation with *z*.

[B.B.C. disapproved.] [K. S.]

HELIOTROPE. [B.B.C. *hĕlliotrope.*]

There are only two objectors to the shortening of the vowel in the first syllable in this word.

There are a good many words beginning with *helio-*, the Greek word for the sun: they are all compounds, mostly very modern, and are always pronounced with long *ē*.

Heliotrope is a very old English word: it kept its Latin termination for a long while—as many plants do to this day—but Bacon (1626) drops it:

Flowers of heliotrope

and Evelyn (1664) has

Star-wort, Heliotrop, French Marigold

and as it is the only *hēlio-* word which has come into common talk, it has so far the right of exception. The dictionaries, however, allow no difference of pronunciation before D. Jones (in 1913) who gives a short *ĕ* without choice, which means that he had never heard the long *ē* spoken, whence it appears very likely that the dictionaries have pedantically ignored an actual use: if not, then this recommended pronunciation must be very recent, but this again is contradicted by the fact that Lord Balfour and Earl Grey both approve the B.B.C.'s ruling; and their practice dates back from an earlier generation, with full scholarly sensitiveness. Hence we are inclined to conclude that *Hĕliotrope* may be the older pronunciation of the two.

I found that both my gardeners said *Hĕliotrope* and, thinking that there might be a tradition among the seeds-

men, I wrote to six firms whose catalogues were handy; four of them replied in favour of *Hĕliotrope*; the other two —perhaps because my question gave them no lead—would not commit themselves, and referred me to the dictionaries. Now these horticulturalists are very dependent on the dictionaries, because the nomenclature of botany is full of un-English problems. They were therefore fighting against their usual authority in sticking to *Hĕliotrope*. Since then I have asked almost every person who came to my house how they spoke the word; and no one of them ever used the long *e*.

[B.B.C. confirmed against all the greater dictionaries.]

HUMOUR. [B.B.C. *h* to be sounded.]

Two of our elder critics object to this aspiration.

The pronunciation of the first syllable of *humour* and its derivatives as *hue* instead of *you* is quite recent, but appears to be gaining ground among good speakers, and can hardly any longer be considered as either a vulgarism, or as a mere whimsical eccentricity, though the more old-fashioned speakers, and those who do not favour a deliberate, studied, or theoretical utterance still adhere to the older, traditional pronunciation. The *Concise Oxford Dictionary* apparently prefers *hue* since it indicates this as the first pronunciation, adding in brackets 'or ū'. The 1918 edition of Annandale, on the other hand, does not mention the aspirated form of the first syllable of *humour*, &c., at all. The 1849 edition of Walker's pronouncing dictionary (first published in 1785) gives 'yumur' as the pronunciation, and mentions no other. It is worth noting that where more than one pronunciation was in vogue, or recognized by authorities, Walker indicates the variants. Thus, under *Herb*, for which he gives 'erb' as the pronunciation, he conscientiously remarks—'I have differed from Mr. Sheridan by suppressing the sound of *h* in this word and its compound *herbage*, and have Mr. Nares, Mr. Perry, and W. Johnston on my side'. It is reasonable to assume, therefore, that in recording 'yumur' as the sole pronunciation, Walker is in accordance with the accepted usage of his time (1732–1807). Sheridan (1780) includes *humour* in his list of words in which *h-* is not sounded. James Elphinston (1721–1809) was the author of various treatises on English pronunciation, published respectively in 1756, 1765, 1787, and 1790. According to this writer *humour*

and *humorous* were pronounced without *h*. Baker in his *Rules for true spelling of English* (1724) strangely enough does not include *humour* in his list of words in which '*h* is not sounded', though this contains *honour*, *humble*, *herb*, *heir*, *honest*.

Convincing evidence, however, for good colloquial usage in the first third of the eighteenth century is furnished by the unstudied spellings of Lady Wentworth—*youmore*, *youmored* (*Wentworth Papers*, pp. 107, 320), and of Cary Verney in the first half of the seventeenth century—*yumer* (*Verney Memoirs*, ii. 63).

The present-day pronunciation of *humour* with *h-* has no tradition behind it and has come in during the last two or three decades. The aspirate in *herb*, *hospital*, *humble* established itself rapidly during the latter half of the nineteenth century, and it is doubtful whether it was ever omitted in these words by good speakers born after the middle of the century. [B.B.C. disapproved.] [C.W.]

IDYL. [B.B.C. *iddill.*]

The B.B.C. ruling here has only one objector among our critics. As he represents the O.E.D. which gives the pronunciation *eye-dil* (recognizing no other), and as Webster does the same for America, and as D. Jones also puts that first, it has to be explained how it comes about that all this learned lexicography is put aside by a consensus of good practice.

It seems clear that this is a case in which a word, finding itself in bad company, retired like a wise homophone from the battle. We have already *idol* and *idle* to say nothing of *ideal*; and the word *īdyllist* (which we are told to accent on the first syllable) is hardly distinguishable from D. Jones's superlative of *idle*.

The Greek pronunciation is of course of no account; and though the syllable was long, it cannot have been *eye* (ai). Mr. Fowler strongly confirms our remarks in his *English Usage*, *sub voc.*

[B.B.C. confirmed.]

IMMANENT. [B.B.C. *immáynent.*]

The B.B.C. suggest an entirely new pronunciation, stressing the second syllable and changing the character of its vowel—and this, with the sole purpose of distinguishing it from the word *imminent*. Two of our critics pass this

utilitarian innovation, while a majority condemn it. There are four words more or less interested in this need for distinction: they are given in the O.E.D. thus:

Emanant. e·mănănt, from Lat. ēmānāre. That which emanates or issues from a source.

Eminent. e·minĕnt, from Lat. ēminēre. High, towering above surrounding objects.

Immanent. i·mănĕnt, from Lat. immanēre. Indwelling, inherent.

Imminent. i·minĕnt, from Lat. imminēre. Impending threateningly.

The word *immanent* is rare, but has a special philosophical connotation, almost consecrated in theology: it belongs to scholars, who will never countenance its deformation, especially one with a false quantity, which implies an entirely different word and meaning—*emanent*, where the long *ā* would be in place. Moreover the B.B.C. pronunciation has an unfortunate likeness to the word *immáne*, which, though useless and entirely literary and almost obsolete, will show its face.

We see here merely an example of the importance of insisting on the articulation of unaccented vowels. The doctrine which many phoneticians now preach, that each word should have only one accent and that one as near the beginning as possible, which should have its vowel distinctly sounded, while all the other syllables should be slurred, leads inevitably to the sort of confusion which is demonstrable in this word.

A speaker who cannot distinguish his vowels should learn to do so and, as Lord Balfour says, 'he must take his chance'. It would seem to us that the simple general rule for these unaccented vowels is that the speaker should have put his mouth in the position of resonance for the proper vowel, and in that condition he is safe and may slur as much as he likes. The only difficulty of this rule is when, as in the present word, the unaccented vowel is followed by a liquid, because the liquid is apt by substitution of its own syllabic quality to override and obliterate finer distinctions, which we readily allow it to do when it makes no confusion. But in a word like *immanent* it should not be allowed its usual licence; the vowel of *man* should be prepared for and distinctly heard.

We therefore increase the majority of the objectors by our vote. [B.B.C. disapproved.]

INDISPUTABLE. See *Disputable.*

INTESTINAL. See *Doctrinal.*

LAMENTABLE. See *Disputable.*

† **LAUNCH.** [B.B.C. the vowel as in law.]

2 objectors.

† **LAUNDRY.** [B.B.C. *au* as in law.]

2 objectors. N.B.—a different pair from those to the last word, *launch.*

OMINOUS. [B.B.C. *ómminous.*]

Two of our elder critics object to the *o*, which is long in Latin, being shortened, but the shortening is in strict rule, and is given in all the dictionaries: the word is not even among Vizetelly's 25,000 frequently mispronounced words: *ōminous* appears as a secondary pronunciation heard by D. Jones (1913); it must therefore, it would seem, have been due to that classical self-consciousness which invaded our speech in the middle of the last century.

[B.B.C. confirmed.]

ORDEAL. [*ordéel*, not *or-dée-al.*]

This is an interesting word, being a rare example of a right and wrong (see Mr. Lloyd James's Preface, p. 8). The question is whether it is a disyllable or a trisyllable.

If you ask any one who says it is a trisyllable how he pronounces *misdeal*, he will suddenly become aware that the *eal* of *deal* is not the adjectival suffix of a root that signifies nothing but that the *deal* in *ordeal* is the same as a *deal* of cards—a word active in all departments of thought and in all ranks of society. It is a true English word more than 1,000 years old.

The earliest spellings of *ordeal* given in the O.E.D. are *ordál*, *ordēl*, *ordale*, *ordell*, *ordele*: it is the same as the modern German *urtheil*, and the digraph *ea* of our modern spelling has the same phonetic value as in *heal*, *meal*, *conceal*, *congeal*, *peal*, *seal*, *steal*, *reveal*, *weal*, *zeal*, &c. The O.E.D. states that it very early got confused with the *ea* in adjectives ending in *eal* as *arboreal*, *lineal*, *corporeal*, &c., and thus *ordeal* was spoken as a trisyllable with the accent on the first, and it is thus quoted from Tennyson. But it is a substantive, and I am sure that I have commonly heard it with the accent on the second syllable of the three and

feel convinced that it came latterly to be associated by Greek scholars with *ideal* and *real*, words of substantive use and of much the same literary status. Thus, as the O.E.D. says, ignorance of the etymology leads to wrong pronunciation. Now though the wrong may yet be too strong for the right, which would not much matter, it was certainly the duty of the B.B.C. to favour the right, and since the word still remains with cultured speakers, there is hope for it. This is one of the words which has three objectors to the B.B.C. ruling: but as it is approved by our two younger critics, we may perhaps conclude that the word is coming back to its rights.

[B.B.C. confirmed.]

†**TROUGH.** [B.B.C. *Troff.*]

2 objectors.

WONT. [B.B.C. *wōnt.*]

This is the substantive or past participle, not the colloquial contraction *won't* for *will not,* with which the B.B.C.'s ruling makes it an objectionable homophone. The uncertainty in their list as to what word is intended, has embarrassed the critics, and one of them writes: 'I don't know whether this refers to *use and wont*, but if so, surely the traditional pronunciation is *wunt*.' And so it is. Prof. Cecil Wyld writes: 'The old pronunciation . . . survives in Spenser's and Milton's rhyme of this word with *hunt*. Milton's contemporary, Wharton, includes it in a list containing *month*, *honie*, *monie*, which, according to him, all have the same sound. This is perfectly normal. *Wont* is historically a Past Participle formation from O.E. (*ge*)*wunian*, "to be in the habit of, accustom oneself to" (cf. O.E. *wuna*, M.E. *wonĕ*, "habit, custom"). Our modern pronunciation, which rhymes with *don't*, is not traditional, but is based on the spelling.' But the old pronunciation is not so obsolete as this might lead us to think. Walker's rhyming dictionary of 1824, under UNT, writes: '*Brunt, blunt, hunt, runt, grunt.* Perfect rhyme, *wont* (to be *accustomed*)'. It is universal in Scotland (it was spoken in my presence last night), and it is universal in America: and, pronounced like *wōn't*, is given in 1924, by Vizetelly, as one of the frequently mispronounced words.

Among the innumerable historical spellings given in the O.E.D. the form *wunt* is given first among those in use

from the fourteenth to the sixteenth century. Mr. Sisam writes: 'The spelling with *o* for *u* arose from an attempt to make good the deficiencies of handwriting. In French and English MSS. of the thirteenth, fourteenth, and fifteenth centuries *u* and *n* are often indistinguishable. Combinations like *un*, *um*, *uu* made obscure groups of uniform strokes; and to avoid them in the body of a word, *on*, *om*, *ou* were substituted in writing without any change in the pronunciation; so that we get *wont* from O.E. *wunian*, *come* from O.E. *cuman*, *love* (older *loue*) from O.E. *lufu*.'

With this word again it appears that Americans have been more conservative than ourselves, and their practice seems to be not only more correct but more convenient.

[B.B.C. disapproved.]

ZOOLOGICAL. [B.B.C. *zō-ŏlŏj-ical*, in Zoological Gardens *zoo-lŏj-ical*.]

The only question about the pronunciation of this word is the value of the second *o*. The first *o* is the long English *o* which we speak in *owe*. The second *o* is either a shortened form of this sound (as heard in *obey* and *violet*) or it is the obscured sound of the true short *o*, as in *hot*, and which we speak in *zoŏlogy*. Daniel Jones, in his dictionary, records that people who visit the Zoological Gardens in London speak of that resort with the following six variants, and he gives them in this order (of frequency?):

zulɔdʒikəl
zuəlɔdʒikəl
zəlɔdʒikəl
zl̩ɔdʒikəl
zlɔdʒikəl
zouəlɔdʒikəl

This picture of the attempts of Londoners to speak *zoological* should amuse them. The familiar nickname *zu*, which seems to be 100 years old and is used not only of the London Zoological Gardens, but of any such collection of wild animals, is now a well-established English word; but as its chief purpose was to substitute one syllable for seven, it loses this advantage and can only be an ignorant vulgarism when it is used to deform the polysyllable. The two proper pronunciations given in this note are equally satisfactory.

[B.B.C.'s alternative disapproved.]

Before engaging in the summary of the results, let the reader remember that the items, as is explained on p. 385, are fewer than was schemed for (though I submit that they are sufficient for their purpose), and that the judgement is quite impersonal. I have merely tried to apply to a haphazard batch of examples the principles which our Society advocates. The verdicts resulting from this process in some cases condemn my own inherited practice.

The circumstances are peculiarly favourable to exhibit the actual condition of these disputed pronunciations:

(1) The words were chosen by the Announcers from practical experience.

(2) A select Committee voted in preference for certain definite pronunciations.

(3) Five careful speakers judged these decisions.

And (4) the S.P.E. comes in with estimation of the philological facts which should determine judgement in each variously disputed case; and it must be by the introduction of some wider principle or knowledge that common agreement can be arrived at. Whether or no I am personally qualified to make this final revision, whether it would in every case have the support of all my colleagues, are points which any one may raise: I only ask that my exposition and arguments shall be taken on their merits.

It was stated that among the five critics there was in 14 cases a majority against the B.B.C. decisions. This number should have been 13, for *disputable* and *indisputable* were numbered as two words. In the following summary all the French words (for the same reasons that led to their separation in the list, see p. 373) will be omitted, except those that had a majority of objectors against the B.B.C.; and all the listed words which have escaped treatment in the tract will be put in [ ] and excluded from the present statistics.

Of these 13 words then, 3 had four-fifths of the critics against them: these were *fotill*, [*laboratory*], [*obligatory*], and in *fotill* we support the B.B.C. against the objectors.

The other 10 words which had three-fifths against them were *acoustic*, [*allies*], [*apparent*], *disputable*, *enclave*, [*fetish*], *immanent*, *ordeal*, [*peremptory*], *trait*; and of the 6 of these which we have examined we support the B.B.C. in 4 cases and support the objectors in 2, viz. *disputable* and *immanent*.

Of the other 18 words which we have treated, 8 had 2 objectors, whom we support in 3 cases; *contumely*, *humour*,

and the alternative of *zoological*: but we confirm the B.B.C. against them in 5 cases; *aerial*, *contemplative*, *fanatic*, *fragile*, *ominous*.

In 4 cases there was only one objector whom we confirm in *evil*: in the other 3 cases, *dynast*, *ephemeral*, *idyl*, we confirm the B.B.C.

The remaining 6 words that we have treated were apparently passed by all the critics. We are therefore opposing both the B.B.C. and the critics in objecting to *docile*, *doctrinal*, *intestinal*, *eyrie*, *furore*, *wont*.

Therefore in the whole 25 words which we have treated we have approved the B.B.C. in 13 cases and gone against them in 12 cases, and in 6 of these 12 we are opposing the whole consensus of the B.B.C. committee and our five critics.

It cannot be supposed that the particular manner in which any one word or any small group of words is pronounced by the Announcers can have noteworthy effect on the trend of the language. On the other hand, it cannot but be that broadcasting of speech must have a very great and wide effect—indeed it would seem as if there had never been any effective influence to compare with it; and though it may no doubt have its bad as well as its good effects, the good must predominate because the main aesthetick of speech is frankly utilitarian: it is the good articulation which is best heard, and the slovenry of our Southern English colloquial pronunciation will expose and destroy itself; moreover there will also be always the personal ambition of the speaker to speak well. And it appears that already the public are becoming more critical and appreciative of good phrasing and articulation. All these influences will work of themselves without interference. But it is most desirable that the speakers should be guided by sound general principles and that is what the B.B.C. intended to assure by appointing a Committee of experts to handle the problems; their intention and doctrines are well formulated by Prof. Lloyd James's preface to their pamphlet.

There has always been plenty of talk about correct speech, but never any sign of concerted action among philological and literary Learned Societies to promote it; although **the fact that we are spreading our language all over the world should quicken our sense of duty and our national pride to do our best to make it as good an organ for thought and discourse as we can.** This from the first

has been the avowed object of our Society. If it were possible to humiliate ignorant people many Englishmen would be humiliated to learn that true English tradition has often been more faithfully observed in America than in London, and that the outspoken contempt of all American speech which was fashionable in England 50 years ago was in this respect less justified than the reciprocal contempt which it provoked in America for our Southern English. In the few chance words which we have treated, there are some half a dozen examples.

This old mutual prejudice still rankles on both sides, but it has never found any echo in our Society, and we can now feel pretty sure that it is practically wiped out, though Americans who wish to be extra smart will still sometimes indulge in the old-fashioned raillery, and on our side we can occasionally hear something to match it.

What is needed in this conflict is what we have already got; that is, a good body of sane students on both sides who are practically agreed on all points and are working for the best unity of the language.

But other things are needed and first of all a hearty **co-operation of our Learned Societies** in a general movement, which it seems to us they would willingly give if they would fairly face the importance of it, and recognize the practical steps that can actually be taken to ensure results.

The first of these would be the **teaching of the vowels in the Board Schools.** I have rarely met any man outside phoneticians, teachers of elocution, and expert philologists who knew the scientific status of the vowels.

When I once said seriously that if I were to have my life again, with one common environment different, I should choose that my teachers should know the alphabet—when I said that, it had no meaning whatever to my hearers, because they all thought I was fooling, for my teachers of course knew the vowels and taught them: '*ay*, *ee*, *eye*, *owe*, *you*, *and sometimes double you and wai*'; but what they did not know was that the great standard vowels had been selected and isolated by human intuition and experience as distinct steps or stages in a scale of musical pitch (this being the simplest natural differentiations of tone and therefore the easiest trick for ensuring audibility), and that these whispered vowel-resonances were effected by certain definite positions of the mouth and tongue.

We have had two tracts on this subject and our circulation ensures that a good many more people are now as well-informed on the nature of the vowels as Roger Bacon was, and perhaps better.

When I was at school, philology had not dawned in England: it was most graciously introduced from Germany by the popular lectures of Max Müller in Oxford some fifty years ago, and since it is now fully domesticated, we have no longer any excuse for not teaching the elements of speech scientifically.

The first step would be to instruct the true vocalization of the great vowels; and this should be practised in all our schools. There can hardly be two opinions about that. Wherever it is suggested the proposition is hailed with such enthusiasm that I suppose everybody recognizes what an overpowering effect it would have for good.

The difficulties, the great difficulties, which in the past may have justified inaction are now almost removed by the cheap multiplication of common machinery for reproducing vocal sounds, and it seems that it needs only a small committee of experts to draw up a scheme which, if it were adopted by the Board of Education, would in a few years bring the articulation and elocution of all our folk to as high a standard, and into as high respect with them as their own speech is with the French.

So long as we refuse to amend our disorderly practice we are under the shame of discourtesy to all who have to learn our tongue, and must bear the reproach that, in these matters, having of all nations the widest responsibility to the world, we are of all nations the worst offenders.

Gray and blue shale and sandstone, with *Spirifer*, *Productus*, *Grammysia*, &c. .. .. Gray and blue shale and sandstone, false bedded.........................	100′ to 200′
Red shale and sandstone..............	Several bands.
Gray slate and sandstone, and bluish, on Elk Run; all north dip..........	100′ to 200
Red shale, on Elk Run...............	15′

Fern Bed.—One mile up Long Run, north of Gaines, where soft gray shales are exposed at a watering trough by the roadside, we obtained a number of *ferns*, the first found in Tioga county. There are several different kinds, some resembling fossil ferns found in Susquehanna Co., Pa., and Delaware Co., N Y., and others probably new. The horizon of these ferns is higher up in the Catskill than that of the shells mentioned in the preceding paragraph.

The Waddles Brook section (in the next chapter) is interesting as showing this fossiliferous character of the Lower Catskill.

Pine Creek Fossils.—Red, gray and bluish beds, occasionally containing fossils, are met with in the bed of Pine Creek at intervals all the way from Gaines to the mouth of Marsh Creek. A little below the mouth of Marsh Creek, along the road, there are twenty-five feet or more of north dipping gray sandstone, somewhat *calcareous at the top;* with traces of *fossil shells* in the upper part. It is underlaid by beds of red shale.

Plants.—Between Middlebury and Keeneyville, in the banks of Crooked Creek, a quarry of tolerably good flag and building stone has been opened in Catskill strata, dipping southward. The only fossils noticeable are carbonized *stems of plants*, which in places form thin seams of coaly matter.

Micaceous Red Shale.—At a quarry on Steven-house Run, in Middlebury township, there is a thin stratum of red sandstone highly charged with particles of mica. This is popularly suspected to be *specular iron ore* because the mica glistens.

Hathaway Ore.—In "Shutler's Hill," south-east of Tioga village, some two hundred feet, more or less, of Catskill rocks, principally red shale and sandstone, may be seen, dipping to the southward. These strata have been further exposed by excavations made in search of an ore, said to combine new and

wonderful properties. Indeed, the hill has been honey-combed with shafts and trenches, and much time and money wasted.

It has been claimed through the local papers that one pound of rock from this hill melted up with four pounds of old cast iron will convert the whole mass into steel. Four pounds of old cast iron, at two cents per pound—eight cents; four pounds of steel, at twelve cents per pound—forty-eight cents; value of the pound of shale used in converting four pounds of cast iron into four pounds of steel—forty cents. Razors, etc., said to have been made from steel thus produced, have been placed on exhibition about the country.*

Lamb's Creek Section.—On a small stream coming into Lamb's Creek, in Richmond township, from the north-west,

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*The real value of "Hathaway's Ore" and of the "Motor Metal," will be better seen from the following extracts from a letter of Mr. M'Creath, dated Harrisburg, Aug. 25, 1876:—

The specimen of "Hathaway Ore" you sent to this laboratory last March has been carefully analysed, with the following result:

Silica	59.630
Alumina	18.560
Sesqui-oxide of iron	8.571
Sesqui-oxide of manganese	.290
Lime	.672
Magnesia	2.252
Potash and soda	5.109
Sulphuric acid	.123
Phosphoric acid	.279
Titanic acid	trace.
Water	4.560
	100.046

The analysis shows that it is simply a ferruginous slate, containing the ordinary constituents of that rock, with a mere trace of titanic acid. The analysis has been very thorough and satisfactory. Nothing exists in the slate aside from what is mentioned in the above table. It contains no gold, silver, mercury, copper, tellurium or palladium.

I have likewise examined with great care certain alloys, so-called, which have been forwarded to me by Mr. G. W. Hathaway and Mr. T. G. Hall, and have made special tests for a "new metal" which they claim to have discovered.

It scarcely seems necessary to say that I have found nothing unusual in these substances. They are not alloys; unless an exceedingly silicious, cold-short, white cast iron can be termed an alloy. I have been especially careful in the examination of these substances, on account of the local interest manifested in the subject.

near H. Dorsett's, the beds, are exposed, dipping north north-west:—

Lamb's Creek Section. Catskill.

1.	Coarse gray sandstone (bottom of X?)	60	
2.	Red sandstone (top of IX?)	12′	
3.	Concealed	5′	
4.	Gray sandstone with a reddish cast	5′	
5.	Concealed	50′	
6.	Red sandstone	10	
7.	Red shaly sandstone	30	
8.	Red sandstone	2′	
9.	Red shale, mottled with green	22′	
10.	Red sandstone	8′	
11.	Red shale	11′	
12.	Gray shale	10′	
13.	*Calcarous* rock, with well-known *Chemung fossils*	0′	10′
14.	Gray sandstone	12′	
15.	Red shaly sandstone	8	
16.	Concealed	9′	
17.	Red sandstone (at the bottom)	2′	
	Total of rocks measured	256′	10′

Below this series, for an estimated distance of one hundred feet, the rocks are concealed. Then we come to gray and bluish beds belonging to the Chemung (VIII).

Seeley Creek Section.—One mile north-east of the last-named locality, and about four miles north-west of Mansfield, on another branch of Lamb's Creek, known as Seeley Creek, there is one of the finest and most interesting exposures of Catskill rocks within the limits of my district. The following section will show the order and thickness of the beds, with their fossil contents:—

Seeley's Creek Section; Catskill.

1.	Red shale, ten feet or more exposed	10′
2.	Red sandstone	20′
3.	Red shale, somewhat mottled with green, and bands of *calcareous* rock. Contains *fish* remains, *plants* and *shells*	4
4.	Red shale	12′
5.	Red sandstone	8′
6.	Red shale	34′
7.	Greenish shale, containing a *Lingula*	4′
8.	Concealed	4′
9.	Gray sandstone	2′
10.	Red shale	20′

11. Gray, *calcareous* band, containing *ten or twelve species of well-known Chemung fossils*.........	0′	6″
12. Gray sandstone..................................	12′	
13. Red shale	6′	
14. Gray sandstone..................................	2′	
15. Red shale	5′	
16. Greenish shale	4′	
17. Red sandstone..................................	15′	
18. Red shale	5′	
19. Red sandstone, ten feet exposed.......	10′	
20. Concealed, at the junction of red and gray rocks known as Chemung and Catskill; estimated thickness....................................	100′	
21. Gray Chemung shale, containing a bed of iron ore, eighteen inches thick (bottom of section),	15′	
	292′	6″

Among the plant remains in No. 3 of the above section, I have recognized a *Sphenophyllum* (*antiquum?*) Shells are not wanting, for I found in it the larger part of a well-marked *Orthonota*.

The fish remains in this bed are its chief attraction. I know of no locality in Northern Pennsylvania so rich in the remains of *Holloptychius*, *Bothriolepis*, *Dipterus*, and other large ganoids. To the casual observer they might escape notice, as it is only by the careful removal of the shale adhering to the thin calcareous slabs that the finer specimens are revealed. I think this spot promises much to the future investigator.

It was from this bed that I obtained the tooth of a new species of Dipterus described by Dr. Newberry, as *Dipterus Sherwoodi*, in Geology of Ohio, Vol. II, Part II, Palæontology, p. 61.*

*The following extracts from his description will show the character of this tooth and the interest which attaches to it:—

"Teeth one inch in length, triangular in outline; crown marked with three prominent tuberculated ridges, separated by deep furrows somewhat wider than the ridges. The strongest of these ridges forms one side of the triangular tooth. On the angle opposite this side are a few irregular tubercles, but no traces of distinct ridges. The denticles which crown the ridges are somewhat depressed laterally, are rounded, smooth, and blunt at the summit.

"This is apparently one of the upper palate teeth of a species of *Dipterus*, and is especially interesting, as being the first relic of that genus found on this continent. It can be readily distinguished from all the species described abroad, by the small number of its radiating ridges.

"In the same rock with this tooth are a number of imperfectly preserved rhomboidal or rounded scales, which are thick and strong, and have the upper surface punctate precisely as in the scales of the foreign species of *Dip-*

Bed No. 11 of the section is also rich in fossils, but mainly of a different character. Ten or twelve species of the most characteristic *shells* of the Upper Chemung are present in considerable number, associated with *fish teeth* and *crinoidal* remains. The height at which these fossils are found in the series above the commonly recognized upper limit of the Chemung series is very interesting.

Tioga River Section.—The following section of northward dipping rocks, made in the west bank of the Tioga river, a little below the mouth of Lamb's creek, and about three miles north of Mansfield, is also interesting as showing the occurrence of *Chemung fossils at a higher level in Catskill strata* than they have been supposed to exist:

Tioga River, Lamb's Cr. Section; Catskill

1.	Red shale (on top)	?
2.	Gray sandstone, with *Spirifer disjuncta*	6′
3.	Red shale	9′
4.	Gray sandstone	8′
5.	*Calcareous* and sandy layers, containing small *Lamellibranchiates* and *Rhynchonella*	4′
6.	Gray shale	1′
7.	Hard *calcareous* rock	2′
8.	Concealed	15′
9.	Gray sandstone	2′
10.	Red shale	3′
11.	Concealed	12′
12.	Red shale	6
13.	Concealed—estimated at	30′
14.	Red shale and sandstone, containing a *Lingula*	20′
15.	Greenish gray shale, containing a *Rhynchonella*	5′
16.	Gray sandstone, *Grammysia elliptica*	6′
17.	Gray and bluish shale	5′
18.	Red shale, four feet exposed	4′
	Total thickness of section	138′

No. 14 contains a bed of red shale four to six feet thick, which has been taken for iron ore and excavations have been made into it under the influence of this belief.

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terus. The surface of these scales was probably once highly polished, but like the fish remains of the Catskill, the organic tissue seems somewhat corroded.

"It is a singular fact, that while previous to last year, [1874,] no teeth of Dipterians had been found in this country, both *Ctenodus* and *Dipterus* were almost simultaneously discovered; one in the Coal measures of Ohio, the other in the Catskill of Pennsylvania."

Fossil Limestone of IX.—A few rods below this spot, behind an island and close down to the water, near the site of an old mill, a stratum of calcareous rock is exposed, two or three feet thick, containing traces of fossil shells. It probably overlies all the beds of the last section.

Catskill rocks may be seen at numerous other localities; as, in the Tioga river narrows, midway between Fralic's and Hickson's mills; at the Mill Creek bridge; at Brace's mill, on Mill creek, where it contains a thin seam of *coaly* matter.

In my study of the Catskill rocks of the Mill creek basin I have encountered the same difficulty, namely, that the rocks possess the *physical character* of the Catskill group in its typical locality the Catskill mountains; *but contain fossils* belonging to the Chemung group. This difficulty seems to increase going west, so as to involve the Upper Catskill also in Potter and M'Kean counties.

It looks as if the Chemung, Catskill and Vespertine, both in their lithological characters and in the number of fossils contained, undergo a marked transformation in their extension from east to west. As we recede from the sand bar deposits of the eastern border we shall see, in the shale and calcareous beds charged with organic remains, the evidences of deeper and more tranquil seas. This change is gradual, affecting the lowest beds first, but by degrees extending to the highest sub-carboniferous strata towards the western part of the State. In my judgment, the line which marks this change constantly runs higher, from one stratum to another, as we proceed to the west, though not at a uniform rate of ascent.

CHAPTER IX.

COWANESQUE ANTICLINAL.

The Valley of the Cowanesque creek lies between the Mill Creek mountain basin on the south, and the Cowanesque mountain basin on the north, and extends for about twenty-five miles from the Potter county line to the Tioga river. Its breadth varies from six miles at its western to ten miles at its eastern end.

The anticlinal axis which runs through it lengthwise crosses the west (county) line of Clymer township two to three miles south of the north-west corner; passes under Sabinsville, and a little to the north of Little Marsh P. O., to the north-west corner of Tioga township; the Tioga river at or near Somer's lane; thence to the north-east corner of the county. It continues its course in the same direction through Chemung county, N. Y.

The south edge of the actual valley is very nearly the line which separates the Catskill red from the Vespertine or Catskill gray rocks, as shown upon the map, and may be said to run from the forks of Long Run in Clymer, past Keeneyville and Tioga, to the south-east corner of Jackson township.

The northern edge of the valley is the south foot of the Cowanesque mountain, rising directly from the north bank of the Cowanesque creek as far as Elkland.

The valley includes more than half of Clymer, a small part of Westfield, nearly all of Chatham, the whole of Farmington and a part of Middlebury townships. The surface is made up of low, rounded hills; the soil is good, and adapted to grain and stock raising.

The drainage of the valley is complicated. The south branches of Cowanesque Creek (Potter's brook along the county line, Mill Creek through Sabinsville, the Jamieson, &c.,) drain its west end, northward; while the heads of Long Run (and Waddle's branch) drain the south dipping country, south-

ward, into Pine Creek. In the middle region, while other small streams flow north into the Cowanesque, the head branches of Crooked Creek drain from the axis at Little Marsh and Shortsville, southward, into the mountain. The eastern end of the valley is drained by the Elkhorn east south-eastward into the Tioga at Tioga village; by Mutton Lane and Somer's Lane Creeks also into the Tioga; while Cowanesque Creek crosses diagonally the valley from Elkland to Lawrenceburg, to empty its abundant waters into the Tioga.

The prolongation of the valley east of the Tioga River is drained westward by Mitchell's Creek south of the axis, and by several brooks north of it, into Tioga River; while Seeley's Creek head waters, Hammond's Cr., Adder Branch, &c. drain into New York State out at the north-east corner of the county.

Tioga River in issuing from the synclinal makes numerous bends up the dip, and trends away east of north in order to get through the anticlinal, after which it resumes its north course straight down the dip into New York. This conduct of the river is a curious repetition of its behavior after leaving the Blossburg synclinal to cross the Mansfield anticlinal.

It is very remarkable that Pine Creek, flowing in the opposite direction (southward) deflects towards the west in its approaches to the anticlinals, as the Tioga deflects to the east going north.

The central surface belt of gray, fossiliferous, Upper Chemung rocks is 3½ miles wide at the west line, and 8 miles wide across from Elkland. They are exposed for 5 miles along the river below Tioga, to the State Line, and the belt continues 5 miles wide into Bradford county.

The red color on the map will show how the Lower Catskills border the Cowanesque banks as far as Elkland, and soon come to an end, leaving all the southern country of New York State with a rolling surface of Chemung.

The southerly dip may be seen in Clymer township, on Waddle's branch of Long run, between M. W. Newton's and L. Blue's; in Tioga and Farmington townships, along Elkhorn creek; along the Tioga railroad, opposite the village of Tioga; and at many other places south of the axis.

The northerly dip may be well seen in Westfield township; on Mill creek and the Jamieson; in Lawrence township, along the Cowanesque, above Lawrenceville, and elsewhere. The angle of inclination is extremely gentle, but perceptibly increases as we approach the mountains, and is somewhat stronger to the south than to the north of the central anticlinal.

Exposures of VIII and IX.—The best are on Waddle's brook, in Clymer township, where portions of both the Chemung and Catskill are visible; on Elkhorn creek, in Tioga and Farmington townships, where the upper part of the Chemung appears; along the Tioga railroads, opposite Tioga, where a very fine section of Chemung rocks can be got, and in a cutting of the Cowanesque railroad, two miles west of Lawrencetown, on lands of Thomas Knapp, where over a hundred feet of Chemung strata are exposed.

The Chemung rocks, it may be said in general terms, repeat themselves along this Cowanesque valley under the same aspect as along the Wellsborough and Mansfield valley, excepting that there are *more gray* and *fewer bluish and greenish* beds, especially towards the bottom of the visible mass.

I have little doubt that beds which further south I have placed in the Catskill have here become a part of the Chemung.

Such rocks form, then, the surface over the northern two-thirds of Clymer; the south-eastern third of Westfield; all Chatham, except a narrow border on the south, and and another at the north-west corner; a part of Deerfield, comprising the south-east corner; the valley of Holden Brook, and the valley of the Cowanesque as far up as the mouth of Troop's creek; all Elkland and Osceola, except a narrow border along the State line; all Nelson, Farmington and Lawrence; the north-west third of Middlebury and Tioga; and all Jackson, except a border on the south.

And in Bradford county:—all Wells township, except a few ridges capped with red shale in the vicinity of Old Hickory Post Office.

Waddell's Brook Section of VIII and IX.—This fine exposure in Clymer township, near the Potter county line, is especially valuable for showing the junction of the Chemung and Catskill groups. Specimens illustrating the physical characters of each

bed were collected for the museum of the Survey. The section begins at the top with the red Catskill beds, and passes down into the Chemung, the dip being pretty rapid southward

Waddell's Brook Section ; IX, VIII.

1. Gray shale and sandstone, with *Rhynchonella* and other *shells*	30′
2. RED SHALE [characteristic of Catskill]	3′
3. Gray shale and *calcareous* rock in thin bands, with two species of *fossil shells*	9′
4. RED SHALE, with poorly preserved *fossil shells*	1′
5. Gray sandstone	1′
6. RED SHALE	4′
7. Gray shale and shaly rock, gray sandstone and *calcareous* rock with *fossil shells* at intervals. This is at Mr. Blue's	100′
8. RED SHALE	8′
9. Gray sandstone	4′
10. RED SHALE	10′
11. Gray sandstone, shale and *calcareous* rock	75′
12. RED SHALE and shaly rock	15′
13. Concealed	25
14. Gray sandstone	2′
15. Concealed	10
16. Gray shale and shaly rock	10′
17. Mottled or variegated shale (red and green)	2′
18. RED SANDSTONE	1′
19. RED SHALE (*lowest of the red beds*)	3′
20. Soft gray and bluish shale, with fragments of *iron ore* in the creek	65′
21. *Calcareous* rock, with *fossil shells*	2′
22. Gray, thin-bedded sandstone	5
23. Soft gray shale	15′
24. Gray, thin-bedded sandstone	8′
25. Soft gray shale	4′
26. *Calcareous* rock, with *fossil shells*	4′
27. Soft gray and bluish shale	20′
28. *Calcareous* rock in thin bands, with *fossil shells*	4′
29. Soft gray shale	10′
30. Gray sandstone and *calcareous* rock, with *fossil shells*,	5′
31. Concealed	30′
32. *Calcareous* rock, with *fossil shells*	3
33. Gray, thick-bedded sandstone	8′
Total measured thickness of section	496′

This section is between the farms of M. W. Newton and J. Davis. Chemung fossils of well known species can be found in nearly every bed of it; but they are not always well preserved in the upper beds. I have no doubt that all the beds above No. 20 would be found to be non-fossiliferous at a dis-

tance of less than forty miles towards the south-east; and that the red beds would be found to have increased in number and thickness, if they could be continuously traced.

The iron ore mentioned above as occurring in fragments in the bed of Waddle's Brook, was found to hold, on analysis, not more than between 18 and 19 per cent of iron.

Iron ore is said to show in a bed on Long Run, in Clymer township, in the hill above the road west of D. Jackson's, sixteen inches (at least) being in sight. This is given on the authority of Mr. Henry Baker. The specimens shown me were similar to the Mansfield ore, and the geological horizon would be about the same.

Elkhorn Exposures.—In Tioga township, on Elkhorn creek, Upper Chemung strata are well exposed, dipping pretty rapidly to the south south-east. They are chiefly gray (with some bluish) sandstones, shales, and calcareous layers It was at this locality that I once discovered the tooth of a new species of ganoid fish named by Dr. Newberry, *Heliodus Lesleyi.**

*The following description of this specimen is by Prof. J. S. Newberry, in the second volume of the geology of Ohio, 1875, Part II, Palæontology, p. 64:—

"Upper dental plate rounded or hippocrepi form, 1½ inches in length and breadth; triturating surface more than a half circle, highest in the centre, where it forms a broad smooth boss; from this radiate eight tuberculated ridges, four on either side of the median line, which is marked by a deep and smooth furrow. The ridges on each side differ among themselves, but are symmetrical with those on the other side, the lateral ridges being shortest, and bearing several tubercles, while the pair which borders the central furrow have but a single tubercle at the extremity of each. On both sides of the central boss the crown of the tooth is worn in a shallow rounded depression by the opposing teeth of the lower jaw. The posterior margin of the crown is nearly straight, and is slightly crenulated at the centre. This is bordered by a sloping surface which extends downward and backward about four lines, and expands laterally to form low, wing-like projections. This portion of the tooth was doubtless covered with integument."

In the description of Heliodus as a new genus based upon this specimen Dr. Newberry says:

"There is little doubt that we have in *Heliodus*, a new member of the family of Dipterine Ganoids to which *Dipterus*, *Ctenodus* and *Ceratodus* belong, and its dental plates present a sample but hitherto unknown modification of the characteristic dentition of the group. In the other genera of the family the palate teeth vary much in form and in the number and character of their radiating ridges. In *Dipterus*, the upper teeth have the form of right angled triangles, or half opened fans, the ridges being set with rounded and generally obtuse tubercles. The lower teeth are longer, like a fan two-thirds opened. In *Ctenodus* the number and form of the teeth is the same as in

Tioga Section.—Along the Tioga railroad, opposite Tioga, is one of the finest exposures of Upper Chemung strata to be found in the county. The following description of its layers in detail may be taken as a type of the exposures of Chemung in Northern Tioga:

Tioga Section; Chemung, VIII.

1. Gray shale..	8′
2. Shale and *calcareous* rocks, with *Spirifers*	8′
3. Gray thin-bedded sandstone, with carbonized stems of *plants*	6′
4. Gray shale	3′
5. Concealed	35′
6. Gray shale	7′
7. Concealed	100′
8. *Calcareous* and sandy beds, with fossil *shells*	30′
9. Concealed	72′
10. Gray shale	20′
11. *Calcareous* rocks, with shell (*Strophodonta*); leaves (*Lycopodites?*); and *fish* remains	3′
12. Gray shaly sandstone	6′
13. Reddish rock, with a considerable percentage of iron, (Place of the second Mansfield ore bed?)	1
14. Gray shaly sandstone	24′
15. Concealed	18′
16. Gray sandstone and sandy shale	15
17. *Calcareous* rock, with fossil *shells*	3′
18. Gray sandstone and sandy shale	7′
19. Concealed	6
20. Thin *calcareous* bands with fossil *shells*, alternating with thin bands of gray sandstone and shale	44′
21. *Calcareous* rock, with fossil *shells*	2′
22. Gray thin-bedded sandstone	6′
23. Gray rubbly shale, with thin sandy layers	38
24. Gray sandstone, with concretionary masses and *calcareous* rock with fossil *shells*	35′
25. Gray shale..	14′
26. Sandy and calcareous rock, with fossil *shells*	7′

Dipterus, but the radiating ridges are generally more compressed, and the tubercles are more acute. In *Ceratodus* the teeth are smooth, the ridges few and large, and without tubercles. Finally, in *Heliodus* we have the upper pair of palate teeth firmly joined in one plate, taking the form of a fully opened fan, and bearing radiating tuberculated ridges like those of Dipterus."

Dr. Newberry gives as his reason for concluding that these fish were gigantic Gar Pike, (to speak popularly,) and not Sharks, the fact that the remains thus found are composed, throughout, of true bone, and bear a fan shaped series of ridges, crowned with little knobs of tubercles, the summit of which are coated with enamel. No such structure as this is known to exist in any Elasmobranch fish, their jaws being cartilaginous, and their teeth attached to the jaw by ligaments.

27.	Concealed	6′
28.	Gray shaly sandstone and gray sandy shale	62′
29.	Gray sandy shale, with thin bands of *calcareous* rock in the lower half, containing fossil *shells*	70′
30.	Soft gray shale	3′
21.	Shale and, *calcareous* rock, with *Loxonema*, *Bellerophon*, and numerous *Lamellibranchiates*	3′
32.	Soft gray shale	4′
33.	*Calcareous* rock, with fossil *shells*	1′
34.	Reddish shale and sandstone	8′
35.	*Calcareous* rock, with fossil *shells*	1′
36.	Reddish thin-bedded sandstone	4′
37.	Concretionary rock	7′
38.	Gray shale and sandstone	8′
39.	*Calcareous* rock, with fossil *shells*	1′
40.	Gray shale and sandstone	9′
41.	*Calcareous* rock, with fossil *shells*	2′
42.	Gray sandstone	4′
43.	*Calcareous* rock, with fossil *shells*	3′
44.	Reddish shaly sandstone	3′
45.	Concretionary rock	4′
46.	Gray sandstone	4′
47.	Gray shale and sandstone	4′
48.	Soft gray shale	10′
49.	Concealed	25′
50.	Gray thin-bedded sandstone, at a bridge	20′
	Total thickness of measures	784′

This section extends along the railroad for a distance of a mile and a half, and its great thickness is owing to the uniform and comparatively rapid south south-east dip.

No. 1, the highest bed named, is anywhere from twenty-five to one hundred feet below the bottom of the Catskill formation. Yet it will be noticed that towards the bottom of the series some of the beds have a reddish cast.

No. 11 yields shells, fish remains, and the fern-like leaf of some land plant of the period, (*Lycopodites Vanuxemi ?*) Its lower beds contain specimens of *Strophodonta perplana*, and *S. Cayuta*—shells which I have never seen south of the Mill Creek synclinal, though they are very common between this place and Corning, on the north.

Cowanesque Section.—The following section was made on lands of Thomas Knapp, two miles west of Lawrenceville, beginning in a cutting of the Cowanesque railroad and extending up the hill to the north. Farther to the north, at the State line, and probably five hundred feet higher, on lands of Jacob Zahn, the

surface is strewn with boulders and masses of coarse sandstone, weathering whitish. Their horizon is near the top of the Chemung. The dip of the strata in this section is to the north north-west:

Cowanesque R. R. Section, Chemung.

1.	Gray sandstone and *calcareous* rock, with fossil *shells*,	36′
2.	Concealed	7′
3.	Gray sandstone, one layer containing a peculiar fossil plant, something like a *Dictyophyton*	8′
4.	*Calcareous* rock, with *Spirifers*	2′
5.	Concealed	18′
6.	Gray shaly sandstone and flagging stone	15′
7.	Concealed	5′
8.	Soft light gray shale	8′
9.	Concealed	30′
10.	Bluish sandstone	5′
11.	Gray thin-bedded sandstone	4′
12.	Gray sandy shale	6′
13.	Concealed	7′
14.	Bluish-gray shale and shaly sandstone	8′
15.	*Calcareous* rock, with *Spirifers*, a species of *Fenestella*, etc.	2′
16.	Gray sandy shale, with concretions	9′
17.	Gray sandstone	8′
18.	Gray sandy shale	5′
19.	Gray flaky sandstone, with *Pterinea*	5′
20.	Gray shale	7′
21.	Bluish gray sandstone, with *Pterinea*	12′
		207′

Chemung Conglomerate?—At Mitchell's Steam Mill, on the head of Alder run, and elsewhere in Jackson township, there are large quantities of sandstone boulders, mostly a coarse, gritty rock, weathering white. They cover the ground in many places, and some of them are large, but contain no fossils. The horizon from which they were derived appears to be about two-thirds of the way up the hill, in the Upper Chemung. They look like the rock on Fall creek, in Ridgebury township, Bradford county. The only strata observed in place was a peculiar shale or slate, having a rusty appearance on the surface, and lying not far below the bed from which the boulders came.

Dictyophyton.—Back of the Methodist church at this place we found two specimens of *Dictyophyton tuberosum*, lying on the surface. They are like those at Bath, N. Y., and the place is somewhat similar.

CHAPTER X.

COWANESQUE MOUNTAIN BASIN.

The Cowanesque mountain basin lies next north of the valley last described; and its southern boundary has been described in the last chapter. Its northern wall, overlooking Southern New York, runs through the middle of Brookfield township and the north-west corner of Deerfield, in a line N. 60° E.

It can hardly be called a continuous mountain. It is rather a chain of isolated high hills of Catskill rocks separated by the five principal northern branches of the Cowanesque Creek. The patches of Vespertine or Upper Catskill (X) forming the summits are small and lie upon a broad base of Lower Catskill (IX) about 4 mile wide, as shown by the red color on the map, and terminating in New York State a few miles north of the State line. In fact Norway Ridge, which lies between Camp Creek and Holden Brook, Woodhull township, Steuben county, is the last and most north-easterly of the high, barren hills, whose summits are capped with Vespertine rocks; and I believe that it is the only locality in the State of New York, west of the Catskill mountains proper, where rocks of this same Upper Catskill age exist.

The centre line or synclinal axis of the basin enters Tioga county exactly at the north-west corner, and passes out exactly at the north-east corner of Deerfield.

In its prolongation north-eastward it crosses the Tioga river near Lindley, and runs on midway between Elmira and Horseheads.

All the summits of the range are of about equal height and rise several hundred feet above the country on each side.

The streams dividing the range all head in New York State and flow into the Cowanesque, viz: Potter Brook, the North Fork, Troop's Creek, Holden Brook and Camp Creek. The Cowanesque ploughs a deep furrow-like valley through the body of the mountain, parallel to and a mile or so south of the synclinal axis, from where it enters the county to Elkland. Even where the Chemung rocks appear in the valley of the creek, the red Catskill rocks form the hills on its southern side.

Along the central belt, one or two miles wide, the Lower Red Catskill is covered with the Vespertine gray (Upper Catskill) rocks, much reduced in thickness, and perhaps nowhere retaining on them a residue of the Umbral red shale, Seral conglomerate, or Coal measures, which undoubtedly once covered the country.

North dips may be noticed on Potter brook, Mill creek, and at various points along the Cowanesque; above Knoxville, near Elkland; and above Lawrenceville, and on Tioga river.

South dips may be seen on the north fork, about two miles above its mouth, where the road crosses the creek; along Troop's creek, three or four miles above its mouth, and at the head of Holden brook.

Exposures.—Owing to greater accumulations of *detritus*, the rocks are generally not so well exposed in this basin as in those already described farther south.

Lower Catskill (IX) may be seen in the banks and bed of the Cowanesque, a little above Knoxville; on Troop's creek, at the Knoxville bridge; and at a quarry a short distance above.

Upper Catskill (X) may be seen jutting from the brow of the mountains in many places on the north side of the Cowanesque.*

The Catskill rocks of the Cowanesque basin vary but little from those of the Mill Creek basin, except that the thickness is not so great. There appears, also, to be more sandstone and less shale, more gray and less red, and more beds with fossil shells.

The belt of red rocks south of the synclinal axis, running through the central part of Westfield and Deerfield, the north-

* I am unable to affirm positively whether or not any strata higher in the series than this occur on these mountains.

west corner of Chatham, and the north edge of Osceola and Elkland townships, is connected with the belt of red rocks on the north, running through the Central part of Brookfield and the north edge of Deerfield, into the State of New York, through the valleys of all the larger creeks coming into the Cowanesque from the north; for the dips are so exceedingly gentle that they nowhere carry these rocks below the beds of the streams.

The red rocks cap the hills in the south part of Steuben county, New York, but do not appear to reach as far east as the Tioga river.

Exposures are numerous, but generally not of much extent, and I have found none of special interest.

NOTES.—The thinning away of the Red Catskill formation (IX) in a direction towards the north-west is a marked feature of the district, and was illustrated in the survey of 1841 by diagrams, two of which appear on pages 310 and 312 of Prof. Rogers' final report of 1858. These are re-produced in Fig. 4, and placed face to face to make the facts more evident to the eye. One was made up the side of the Blossburg mountain, east of the Tioga river; the other up the south flank of the Crooked Creek mountain a few miles *north* (not *south*, as the legend to fig. 44, F. R. 1858, Vol. I, p. 312, makes it) of Wellsborough.

These sections were made at points not more than fifteen miles apart, and yet the Red Catskill (IX) has diminished in thickness to one-third; as is proven by the presence in both sections of the limestones in their regular place near the base of the Upper Gray Catskill (X.)

This *Vespertine Limestone* is fossiliferous, and overlies a bed of bluish sandstone, eight to ten feet thick. It shows itself in large blocks in the railroad cuttings three miles below Blossburg, where the dip of the mother rock is from 6° to 8° S. S.E.

In the Cowanesque mountain the Upper Gray Catskill (X) is very much reduced in thickness, and the Lower Red (IX) still more.

At Knoxville the north dip of the Chemung rocks in the creek is 2°.

On Troup's creek, a half mile above its mouth, at the saw mill, where thirty feet of red shale appears, containing so much iron that ore bogs are formed by the springs which issue from the foot of the hill, the first overlying 200 feet of rocks in the mountain side are of green *Chemung* sandstone, as shown by the characteristic pink soil, and the fragments covering the surface.

Above this, on the slope, are seen *in place* the thin-bedded, *Upper Catskill* sandstones, showing the characteristic false bedding and pitting of the fractured surfaces with black specks. This is a very interesting feature of X when considered in connection with the discovery of small coal beds in this formation in other counties of the State.

Near Knoxville the thickness of X would be 500 feet if measured up to the heavy outcrop of white sandstone, (XII?) since there is no appearance here of the red shales of XI, (although its ore appears eight miles further west,) nor much appearance of any true red rocks of IX.

The Mansfield ore (and red shale) was recognized in 1841 on one of the high hills eight miles south-east of Knoxville and nearly on the anticlinal axis, on the road to the forks of Crooked creek. No limestone was seen there. At Knoxville the limestone must underlie the surface at no great distance; as it was opened on the Cowanesque creek, two miles below Knoxville, showing two feet of poor, fossiliferous limestone.

If this be the Mansfield Chemung ore, red shale and limestone, and not Red Catskill, then the Lower Red Catskill has thinned away to nothing, or has entirely changed its character.

Note, on the Extension of the Anticlinals and Synclinals through the State of New York, towards Albany.

The connection between the synclinals and anticlinals which are observed crossing the Delaware river, with the synclinals

of Carbondale and Tunkhannock, and the Harvey's Lake and Wilmot anticlinals cannot be doubted, although they have not yet been carefully traced from the Delaware to the Susquehanna rivers. The proof is afforded by the geological map of the State, (1858) in the sweep of the Wilkesbarre, Scranton and Carbondale coal basin upward to the north-east, and the parallel sweep of the Tunkhannock Creek mountains.

No attempt has been made in the progress of the survey of Tioga and Bradford counties to follow the Wilmot and Towanda anticlinals through Susquehanna county. This must be left for another season. But to show that these great waves are not confined to Pennsylvania, it is well to name certain localities in New York State where the Tioga county waves have been followed and noticed.*

The Crooked Creek (Mill Creek) synclinal axis crosses the Chemung River between Wellsburg and Chemung, from whence it runs past Owego on the north to Chenango Forks, on the Chenango, and thence through Rockdale on the Unadilla, to West Oneonta and beyond. Evidence of this is seen in the north-westerly dips mentioned above, in connection with the Mansfield and Wellsboro' axis, and the south-easterly dips on the Chemung, below the mouth of Seeley Creek; at Newark Valley, on Owego Creek; at Oxford, on the Chenango; and Mount Upton, on the Unadilla.

The Sabinsville anticlinal axis leaves Pennsylvania and enters New York where Tioga, (Pa.,) Bradford, (Pa.,) Steuben, (N. Y.,) and Chemung, (N. Y.,) counties corner on each other, It crosses the Chemung River a little below Elmira; the West Branch of the Chenango between Lisle and Whitney's Point, and the East Branch at Norwich, as is clearly shown by the north-westerly dips at Lawrenceville, Elmira, Upper Lisle, etc.; and by the south-easterly dips referred to above in connection with the Mill Creek axis.

The Cowanesque synclinal crosses the Tioga River a little below Lindleytown; the Chemung River below Big Flats; passing midway between Elmira and Horseheads; and crossing the West Branch of the Chenango (Tioughnioga) at Marathon,

*By Mr. Sherwood, under the direction of Prof. Jas. Hall, previous to 1875.

from whence it probably extends into Chenango county. The only evidences in my possession, however, which would tend to show that it extends beyond Chemung county are the topographical features of the country in that direction, and the finding here and there* of a conglomerate, which occurs in the Upper Chemung at intervals over Southern New York and Northern Pennsylvania. I have seen no dips beyond Elmira and Horseheads. At the first of these two places it is northwesterly; at the latter south-easterly.

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*As south of Pharsalia and east of Cincinnatus, Chenango County, New York.

PART II.

COAL BASINS OF BRADFORD AND TIOGA COUNTIES, AND AT THE FORKS OF PINE CREEK IN POTTER COUNTY.

CHAPTER XI.

The Barclay Coal Basin in Bradford County.

The Barclay Coal Basin of Bradford County is a moderate area, included in Barclay and Leroy Townships.

The report of Mr. Sherwood, pp. 1–96 of this volume, and the colored geological map which accompanies this Report, define clearly the limits of the Lower Productive Coal Measures in Bradford County, and explain why they are caught in no one of the synclinals save only in this Barclay basin.

Topographically and geologically the basin is well defined.

To the north of it the Towanda Mountain makes a straight and continuous wall, over 2000 feet high above the level of the sea, though really but little above the level of the table land made by the Coal measures in the centre of the basin.

On its north face the Towanda Mountain falls off abruptly, and the measures of XI and X, clearly defined on this north escarpment, make a pretty rim along that side.

Drainage of the Basin.

The Schroeder Creek heads in Leroy Township, Bradford County, in Fox Township, Sullivan County, and in McIntyre Township, Lycoming County.

These forks unite, and the Creek flows to the N. E., keeping parallel with and south of Towanda Mountain, and distant about 2½ miles from it.

Where the Towanda Mountain points out at Greenwood, in Monroe Township, the Schroeder Creek curves northward around its point and joins Towanda Creek.

Limits of the Basin.

The Schroeder Creek is the practical south line of the Lower Productive Coal Measures in the Barclay Coal Basin. There is indeed apparently a small area of Coal Bed B on the south side of the Schroeder Creek, near the extreme east end of the basin, but it embraces only a few acres, and is as yet but little explored.

Considering the basin as a whole, it may therefore be said that for all purposes of working Coal bed B, the basin is north of the Schroeder Creek.

All of the features above described are plainly shown on the Bradford County Map accompanying this report.

The outline of the area of coal bed B is laid on the map, solid in color where it is clearly defined and worked on the north side of Schroeder Creek, and with a dotted line around it on the south side to indicate the less certain character of that work; but it will be noted that there are no outcrop limits to Coal bed A.

As this bed lies regularly 60 to 80 feet below bed B, its line of outcrop could easily be laid on along the Schroeder; but on the north side of the basin its outcrop is concealed on a broad flat, where a slight change in dip would make a great difference in increasing or diminishing the acreage covered by the bed.

For this reason the Measures are thus sub-divided:

1. Conglomerate of XII, Bed A, and Measures up to Bed B.

2. Coal Bed B and overlying rocks.

Moreover there is reason to believe that Coal bed A is caught in various hill tops west of Sunfish Lake and south of the centre line of the basin.

But in view of the fact that this bed is in the Barclay region as a small though regular bed, not averaging 2 feet in thickness, though in places running up to 3 feet, it was not deemed necessary to examine into and plot every acre where it may have caught in the hills. The country is heavily wooded and only a slow and thorough survey, by a completely organized party and with all needful instrumentation, could locate closely the detached areas.

Many years hence, when bed B is exhausted from the basin, Coal bed A will become valuable, and a thorough examination of its outcrop line will be necessary ; but at present the bed A is of but minor importance, and is nowhere mined in any part of the region.

Outlet for the Coal.

The great value of the Barclay Coal Basin lies in its proximity to its market as well as in the excellent character of the coal as a steam raising fuel. A comparatively short distance places the coal on the line of the New York and Erie R. R. at Waverly ; and 82 miles further puts it upon the New York Central R. R. at Geneva.

Both of these roads for their own use need great supplies of fuel ; and at present all of the product of the Barclay Mines goes to the New York & Erie R. R., and a large part of the Schroeder Mine coal to the New York Central R. R.

The distances are—

Barclay to Towanda, ... 16 miles

Towanda to Sayre, via the Penna. & N. Y. Canal and R. R. Co., ... 21 miles

Sayre is on the N. Y. and Erie Railway.

From Sayre to Geneva, ... 82 miles

Geneva is on the New York Central Railroad.

The acreage of Coal bed B in the Barclay basin is shown on the map accompanying this report. Only a part of this

acreage has been mined out; and the basin will continue to yield at its present rate for many years from bed B alone.

When this is exhausted Coal bed A can be attacked at points where it reaches $2\frac{1}{2}$ to 3 feet of good coal; and as the acreage is much more extensive than that of bed B it will undoubtedly continue to supply coal for a great number of years.

The discussion of the axes bounding the Bradford County Coal basin as well as the Tioga County basins, will be given after the details of the Tioga Coals, when there will be also given all discussions of character of coals, usefulness for specific purposes, &c., as well as relationship to the Lower Productive group of coals as showing in the first, second, and third basins in Clearfield, Cambria, Indiana, and Somerset Counties.

Detailed Report.

The Barclay Coal Basin is a part of a tract of 30,000 acres purchased in 1794 by Robert Barclay, of London, England.

The existence of coal in the region was known at an early date, and some coal was mined soon after the settlement of the county. It continued to be mined thereafter on a small scale and was hauled away in wagons to supply blacksmiths in Northern Pennsylvania and Southern New York.

No geological examination of the region was made until the year 1835 when R. C. Taylor reported upon it. Since then it has been thoroughly developed and opened, and the record of the numerous trial pits and drifts is found in the reports made by Walter R. Johnson (1840) and J. P. Lesley (1853).

These reports covered the whole basin, and made an exhaustive description of the limits of the basin, the area of the different coal beds, and their size, character and accessibility to market. The trial openings are long since closed and cannot now be examined.

Inasmuch as only a small portion of the Barclay region is as yet worked out, these facts of Professors Johnson and Lesley are of as much importance as ever in enabling a

judgment to be formed of the structure, area, and future yield of the basin. These reports therefore will be freely drawn upon for such facts as are not now accessible without special opening for the purpose, and to these facts will be added the observations made during the State Geological Examination of the basin in 1877.

It is not necessary to reproduce any facts from the report of R. C. Taylor made in 1835. It was simply a preliminary report, made without much opening up of the outcrops; it reported generally the existence of a coal basin, holding coal beds A and B; and that the basin was of sufficient area to justify its complete development and the expenditure of the money necessary to provide an outlet to market.

Report of Prof. W. R. Johnson.

Five years later (in 1840) Prof. Walter R. Johnson, with an efficient corps of assistants, and abundant time and means, made an examination of the region, defining somewhat generally the outcrop lines of the coal beds, opening up and examining the coal benches at numerous points, defining the size and character of Coal beds A and B, as well as the iron ore deposits, and finally locating a railroad line down Schroeder Creek to afford an outlet to the Susquehanna River.

Johnson's statement of facts can best be given in his own order and in his own words.

"The most important portion of the Coal of this formation appears to be included in two principal beds, known as the upper or "big vein" and the lower or "three feet vein." The upper bed has been exposed in six or seven different places, and has an average elevation of 1219 feet above the level of Towanda.

The lower bed, where exposed, not far from the head of Fall Creek, is at an elevation of 1112 feet, but to the southwestward of this point, the same bed is found at a higher elevation.

The lower bed, where opened, at the southeast side of Fall Creek, near its head, was measured, and gave the following vertical section, beginning at the top:

	Ft.	In.
1. Sandstone, about,	30	
2. Slate and Iron-shale,	2	
3. First, or upper ply of *Coal*,		12½
4. First ply of Slate, intermediate,		5
5. Second ply of *Coal*,		2
6. Second ply of Slate,		4
7. Third ply of *Coal*,		9½
8. Third ply of Slate,		1
9. Fourth ply of *Coal*,		4
10. Fourth ply of Slate,		2
11. Fifth ply of *Coal*,		5½
12. Fifth ply of Slate,		6
Total *Coal*,		33½

The last ply of slate rests on a white gritstone, 5 feet in thickness, below which occurs a stratum of gray sandstone; and under that fireclay four feet thick.

The southwestern opening, which has been hitherto supposed to be on the same bed, has exhibited a more unmixed series of coal-seams, viz:

	Ft.	In.
1. Sandstone, as before, about,	30	
2. Top slate,	4	
3. Upper *Coal* Seam,		16
4. Upper Slate,		2
5. Second *Coal* Seam,		15¾
6. Second Slate,		4
Total *Coal*,		31¾

The coal in this drift is not only less separated into thin plies than the other opening, supposed to be on the same bed, but is of more uniform texture. The *mining ply* in this bed, is a stratum of four inches of soft slaty matter, two inches above the upper seam of coal, constituting part of the four feet of *top-slate.*

The next series of measurements which I made on the Coal beds, was near the old cabin, at the end of Miller's coal road, and in the eastern opening. The pit sunk at this point was too near the outcrop to enable me to decide with entire accuracy all the points in regard to either the the thickness or elevation of the seams. The gradual decaying and breaking down of the stratification on the slopes of the mountain, often render the measurements

taken at the surface of the ground uncertain; and the uncertainty is the greater as the materials below the coal are more perishable and easily washed away. The top of this bed appeared to be 1201.6 feet above our base line, and consequently, 89.6 feet above the level of the first opening above described, and 52.6 feet above the second.

The series was as follows:

	Ft.	In.
1. Covering of Sandstone, much broken,	4	
2. Iron-shale,	3	
3. *Coal*.		32
4. Slate,		15½
5. *Coal*,		8½
6. Slate,		1½
7. *Coal*,		13
8. Slate,		14
9. *Coal*,		29
Total *Coal*,		82½

The lower ply only of coal had here any degree of cohesion, owing to the nearness to the outcrop; but the distinctive character of each seam, both of coal and slate, could be readily discriminated.

The fourth opening, in which measurements were taken, was about 300 feet N. 56½° W. from the preceding, in what has been called Miller's Old Drift, near the cabin, at the end of the coal road. The roof of this opening is 1212.6 feet above our base line, and 10.9 feet above that of the preceding opening. Its covering is iron-shale, with some iron ore intermixed, above which is sand-rock as above described:

	In.
1. *Coal*,	32
2. Slate,	4
3. *Coal*,	19½
4. Slate,	7
5. *Coal*,	21
Total *Coal*,	72½

The above were all the strata exposed in this drift, in a manner to be easily approached or measured.

I had an opportunity of measuring the thickness of the bed on which Barclay's mines are opened, at a distance of

a little more than one and one-third miles, in a direct line, bearing South 81° West from the Old Drift just described. I then found the following section, viz :

Under a covering of sandstone is a roof of nine inches of slate, and then—

	In.
1. *Coal*,	35
2. Slate,	11
3. *Coal*,	6
4. Slate,	5
5. *Coal*,	20
6. Slate,	3
7. *Coal*,	6

Total *Coal*, 67 inches, of which 61 inches are worked.

The level of this bed does not lie more than 20 feet above that of the Old Drift near Miller's cabin.

It is a well-known fact, that where coal and slate seams alternate in the same bed, the relative thickness of the several plies of the two materials may vary very considerably within a few hundred yards. This may suffice to account for all the differences which have been observed on the superior bed of coal in this basin. It would not be safe, however, in a country so little explored, and so much in its primitive condition of a deep forest, to pronounce against the existence of more than two beds which I have laid down. These are certain, and their existence is sufficient to stamp a value on the region which it will require a long period to exhaust.

Analysis of Coal.

Eight samples of the coal of this region have been examined.

No. 1. This specimen is from the fifth ply of coal, in the lower bed, opened near the head of Fall Creek:

	Per cent.
At a temperature of 300°, it loses of moisture,	1.3
By distillation at a red heat, it loses of water,	4.5
Uncondensable gaseous matter,	9.2
It contains of Carbon,	62.6
And of earthy matter,	22.4
	100.0

The ashes are almost perfectly white, and of moderate density. This, as well as the two following specimens, are from parts of the bed so near the outcrop as to yield, as in all similar cases, a higher proportion of earthy matter than would be found to exist in the coal when not exposed to the decomposing influence of the atmosphere.

No. 2. This specimen was from the third ply of coal, in the same opening as the preceding.

The thickness of this ply is 9½ inches.

Its specific gravity is 1.4485.

	Per cent.
At 260°, it loses of moisture,	1.9
At a bright red heat, it gives of water,	6.2
At a bright red heat, it gives of gas,	9.3
It contains of carbon,	70.
And of earthy matter,	12.6
	100.0

The ashes are dense, and of a grayish white color.

No. 3. This sample is from the second ply of the same bed, the thickness of which is two inches.

	Per cent.
At 220°, it loses of moisture,	1.2
At redness, it is decomposed, giving of water,	5.7
At redness, it is decomposed, giving of gas,	12.2
It contains of carbon,	63.9
And of earthy matter,	17.0
	100.0

The ashes are light, and have a white color, slightly inclining to buff.

No. 4. This sample of coal was taken from the Old Drift of Miller's opening, northwest of the head of Fall Creek, and from the middle coal of that bed, which is 19½ inches thick. Its structure is somewhat irregular, inclining to rhombic, and its color rusty brown. The surfaces of deposition presenting distinct traces of vegetable fibres in a state of charcoal.

Its specific gravity is 1.3771.

	Per cent.
It loses in moisture at 220°,	2.5
At a red heat, it parts with water,	3.0
And of combustible and other gases,	15.0

It contains of earthy materials,	11.4
And of carbon,	68.1
	100.0

The ashes of this coal are almost perfectly white, or but very slightly inclining to buff.

No. 5. This specimen is from the lower part of the upper 32 inch ply of coal in Miller's Old Drift, and possesses a cubical structure, with a specific gravity of 1.3784.

	Per cent.
It possesses of hygrometric moisture,	1.0
Water given out in coking,	3.5
Gas volatilized by bright red heat,	14.7
Carbon,	65.5
Earthy impurity,	15.3
	100.0

The ashes are moderately light, and of a gray color, compounded of white and chocolate.

No. 6. This sample was likewise from the upper 32 inch ply of Coal in the Old Drift before mentioned. It possessed the cubical structure, and a fine, deep black color.

Specific gravity 1.3492.

	Per cent.
It contains of moisture vaporized at 212°,	1.3
Of water, tar, &c., disengaged in coking,	6.5
Uncondensable gas,	11.5
Carbon,	74.97
Earthy matter,	5.73
	100.00

The ashes are of a rather deep chocolate brown, scarcely less marked in this particular than any of the red ashes of Anthracite.

No. 7. This coal was obtained from the middle of the bed at Mason's Mine, on the head waters of Wagner's Run. The coal from this mine is already in the highest repute both for domestic consumption and for purposes of the arts.

It has a specific gravity of 1.388.

	Per cent.
Matter volatile at 390°,	0.6
Vapors condensable,	2.8
Uncondensable gaseous matter,	15.4
Carbon,	68.1
Earthy matter,	13.1

The ashes of this coal are white, slightly inclining to buff, moderately bulky.

No. 8. This coal is from the lower part of Mason's bed. It possessed a columnar structure, the surfaces of deposition being distinctly marked; its color deep black; surface of vertical fractures shining.

Its specific gravity is 1,400.

	Per cent.
Water lost at 340°,	2.1
Volatile matter expelled in coking,	16.8
Carbon,	68.57
Earthy matter,	12.53
	100.00

The ashes of this Coal are of a white color, rather inclining to gray, and not remarkably heavy.

Experiments to detect the presence of sulphur succeeded in giving faint traces of that ingredient.

From all the analyses of the Coal detailed in this Report, we have the following table of general results: *

No.	Carbon.	Vol. Matter.	Earthy Matter.
One,	62.6	15.0	22.4
Two,	70.0	17.4	12.6
Three,	63.9	19.1	17.0
Four,	68.1	20.5	11.4
Five,	65.5	19.2	15.3
Six,	74.97	19.3	5.73
Seven,	69.00	17.9	13.1
Eight,	68.57	18.9	12.53
Mean,	67.83	18.41	13.76

Thus it appears that the quantity of volatile matter in this coal is small, compared with that of most other bi-

* Coals numbered 1, 2, and 3, are from *Coal bed A*. The average of the three analyses is:

Carbon.	Vol. Matter.	Earthy Matter.
65.5	17.17	17.33

Coals numbered 4, 5, 6, 7 and 8 are from *Coal bed B*. The average of the five analyses is:

Carbon.	Vol. Matter.	Earthy Matter.
69.23	19.16	11.61

tuminous coals of our country. Being situated on the eastern extremity of the first principal range of bituminous coal-formations west of the Susquehanna River, it adds another to the many evidences which have been derived from my own experiments, in proof of the position long since advanced, that the quantity of volatile matter in the coals of Pennsylvania, and other States, gradually increases as we advance from the Atlantic region, across and beyond the Alleghany Mountains, over the great coal fields of the Western and Northwestern States.

This law becomes the more striking when the Anthracite fields are embraced with the bituminous, for there we have a series commencing almost at Zero, and proceeding upwards in the scale of volatility, till in some of the coals of Kentucky, Illinois, &c., it attains a maximum of 48 or 50 per cent. The circumstance of possessing but a moderate share of bituminousness is favorable to the application of the coals of this region to the purposes of iron manufacture, and though the percentage of earthy matter is higher than that of some other coals, yet it will be recollected that nearly all the samples are taken from points near the outcrop of the respective beds, and that consequently the relative proportion of earthy matter is likely to be higher than would result from the coals taken a few hundred feet from the edge of the same beds.

Iron Ores.

The argillaceous carbonate of iron is the principal variety to be expected in all coal districts. The Carbon creek formation is found in this respect to sustain the general character of all our Pennsylvania coal fields, yielding ores in considerable variety, and of different degrees of richness, capable of producing from six or eight, to forty or fifty per cent. of metallic iron. These ores have been found either in place in the solid strata, or scattered in rolled pebbly masses, over so much of the property as to leave no doubt of their constituting, originally, regular portions of the formation. Thus I have collected samples from the heads of Fall Creek, and from those of Long Valley, as well as along

the *channel* of the latter tributary; they are also met with in Wagner's Lick Creek, and especially on the heads of the latter stream, where the ore has been fully exposed a few hundred yards from Mason's coal mines. Kidney ore is found in several places directly overlying the upper bed of coal.

The lowest stratum of ore which I have been enabled to examine, is situated, as above mentioned, 1016 feet above the level of our base line, such at least is the elevation where opened on Fall Creek. It constitutes a bed 37½ inches thick, reposing on a bed of fireclay, 16 inches thick, and covered with a ferruginous shale, 6 inches thick. From this statement, it will appear that the mining of this ore will be effected without any unusual difficulty.

In the solid part of the stratum, where the influences of the weather have not interfered with its natural state, it is of light blue color, of irregular texture, being sometimes uniform, and at others conglomerated of clay and fragmentary masses of iron ore. The weathered specimens are commonly of a dark brown color, approaching to black, and are obviously changed from the character of carbonates of the protoxide to hydrated peroxides of the metal. As in passing through this change some portions of earthy matter are commonly separated and washed away, the ore in this latter condition is richer than in its previous state of a carbonate, the *loss* in carbonic acid and earthy matter being greater than the *gain* in oxygen and water. This remark will also apply to the other carbonates, as compared with the hydrated parts of the balls or blocks of ore. In the process of decomposition the hydrate is often accumulated in the form of a shell, more or less regular upon the exterior of a nucleus of spongy earthy matter, nearly destitute of iron; such shells are occasionally found in the bed now under consideration. The following are the results of my examination of this ore:

No. 1. A specimen of this ore from near the outcrop was selected, having the elongated kidney form, a shell enclosing white earthy matter, its color in recent fractures of the shell, dark brown.

Its specific gravity was 3.2264 at a temperature of 56° Fah. It lost at 320° 2½ per cent. of water; and by the application of a white heat for some time, the combined water expelled amounted to 21.1 per cent.

An assay of this ore in the dry way, without any admixture whatever, gave of metallic iron, 32.5 per cent., and of earthy cinder, 29.8 per cent.; oxygen, 14.1 per cent.; water, 23.6 per cent.; of which 2.5 per cent., as above stated, was uncombined.

This analysis proves that for each equivalent of iron, in combination, (28), there was present 1½ equivalent of oxygen (12) and 2 equivalents of water. This corresponds with the constitution of bihydrated peroxide of iron.

The pig metal obtained in this assay was of a light grey color, and rather brittle. This trial proves that the ore will not actually require the use of any flux for its reduction.

No. 2. This sample was taken from under the fall, below the lower bed of coal, and was in the original state of the mineral, not changed to hydrate as in the preceding example. Its color is light blue, its texture is amorphous, or foliated, its fracture irregular; some shining particles, probably pyritous, are distributed through it.

Its specific gravity is 3.0549. At 320° it loses 0.5 per cent. It loses when heated to whiteness, 10.5 per cent. of carbonic acid, with probably a little sulphur. The amount of iron contained in this ore was 24.2 per cent.; of earthy materials, 49.2. The state in which the iron exists in this ore is doubtless that of a proto-carbonate. The cinder was brittle, of a green color, and perfectly fused.

No. 3. This ore was taken from the fifth ply of a bed about 10 feet in thickness, and at an elevation of 1,080 feet above our base line, and 64 feet above the 37½ inch bed already described. The ply is 18 inches thick.

This ore has a brown or ochrey appearance, and being taken from a point at no great distance from the outcrop, has evidently undergone a change from atmospheric influences. Its fracture is uneven, and its texture analagous to some of the argillaceous shales. Its specific gravity is 2.7256. It contains of hygrometric moisture, vaporizable

at 320° Fah. 2 per cent.; of water in combination 4.8.; metallic iron 44 per cent.; earthy matter, 24.3.

The remaining 4 portions of the 10 feet bed, from which the preceding sample was taken, were examined and found to yield different quantities of iron, from 6 to 16 or 20 per cent. It is probably that in working some of the other varieties of ore found on the Company's domain, portions of this 10 feet bed will be found available as furnishing materials to promote the fusion and facilitate the working of the richer descriptions, which do not contain a sufficient quantity of earthy ingredients to produce a good cinder for the protection of the iron in the hearth.

No. 4. This sample is from a stratum of iron ore and fire clay found on Fall Creek, at an elevation of about 46¾ feet above the lower bed of coal, or 1,158 feet above our base line; the bed of materials in which it occurs is 2 feet 6 inches thick, of which 4 inches at the bottom are fire clay, the remaining portion iron shale, intermixed with flattened reniform masses of argillaceous carbonate of iron, and some carbonaceous matter derived from fossil vegetable remains. The whole bed, together with the superincumbent mass of sandstone rock, or fine conglomerate, appears to have fallen from place, and the situation was not therefore favorable for determining the real value of the bed. The sample submitted to experiment was a fair type of the ore in this bed; but it should be added, that all which we could conveniently obtain at this place had undergone a change, and been reduced from carbonate to hydrate. Its specific gravity was found to be 3.2113.

It lost of hygrometric moisture,	3.5	p. c.
Of combined water, expelled by a full red heat,	12.7	"
Pig metal,	53.4	"
Earthy matter,	5.8	"
Oxygen,	24.6	"
	100.0	"

The pig metal is of good quality, soft, gray and tough. The cinder was imperfectly fused, but with 20 per cent. of lime would probably be fully reduced.

In the assaying of other parts of this band of 10 feet of

argillaceous ore, a friable, semi-vitreous cinder was obtained by the use of one twentieth its weight of carbonate of lime; but the large quantity of earthy matter in the ore would demand in practice considerable increase of that quantity, probably to the extent above named.

No. 5. This ore was discovered on the head waters of Long Valley creek, in a decayed and broken down portion of the measures, in such a situation as induces me to believe that its original place in the formation is near the level of the lower bed of coal, probably a little above it. Its color is brown externally, and yellowish within; it is evidently a hydrate, formed by the decomposition of carbonate.

Its specific gravity is 3.3604.

It lost of water, by heating to 320°,	3.8	p. c.
And at a white heat,	14.1	"
Of pig iron, it gave,	48.4	"
Earthy material,	3.9	"

The pig metal was gray, tough, and moderately soft; the cinder opaque, grayish white. In this assay the cinder was rather imperfectly reduced, and some portions were probably lost.

No. 6. This specimen of ore was taken from a pit sunk about 8 feet deep, near Mason's coal mines, on the head waters of Wagner's Run; the band of flattened balls, very closely compacted together, is 6 inches. This band of ore is found near the north-easterly outcrop of the series of coal measures, a few feet only above the level of the heavy stratum of conglomerate rock which marks so distinctly the limit of the basin in that direction. In this same locality are exposed three other strata of ore, the first of which is 5½ feet above the one now under consideration, the second 6¾ feet, and the third about 7½ feet. This last is a band of balls, as will be more particularly stated below; hence it will be seen that all four of these bands of ore may be worked together within a vertical height of 8 feet. The total thickness of the four bands being about 18 or 19 inches, and the intervening matter to be mined out ferruginous slate and rather friable sandstone, will not, I apprehend, present any serious difficulties in the mining.

The following section shows the whole of these measures, commencing at the top:

	Ft.	In.
1. *Balls of iron ore*,	0	3
2. Slaty sandstone,	0	9
3. Upper *band of iron ore*,	0	6
4. Silicious iron shale,	1	0
5. Middle band of *Kidney ore*,	0	5
6. Ferruginous slate,	5	0
7. Lower band of compact *balls of iron ore*,	0	6
8. Iron shale,	1	6
9. Black slate,	0	6
10. Iron shale,	1	8

The four varieties of ore found at the above locality are also met with in various other situations on the property, especially on Long Valley creek, in the bed of which samples exactly similar to the lower band of the above section have been observed in numerous places. This band is of a durable texture, and appears to resist more firmly than the accompanying materials, the decomposing action of the atmosphere, and hence it continues unaltered in places where all the others have been washed away. The specific gravity of this lower band is 3.265.

It loses by calcination,	22.7	per cent.
And gives of iron,	29.4	"
Earthy matter,	36.7	"
Volatile matter, oxygen, &c.,	11.2	"
	100.0	

No. 7. This is the middle ply of the ore in the bed near Mason's coal mines. It is found in a stratum of kidney shaped balls, 5 inches thick. Its color, in fresh fractures, is dark bluish gray, surface splintery, occasionally giving conchoidal fractures, compact, and of uniform texture.

Its specific gravity is 3.763.

Heated to 320°, it loses but	0.2	per cent.
Fully calcined, it loses in addition,	29.8	"
Treated with pure lime it yields at once malleable iron, with a little oxide,	45.0	"
Earthy impurity,	4.1	"
Oxygen,	10.9	"

This stratum affords the richest ore which has fallen under my notice from any coal formation, for the sample

above analysed was not a surface specimen, reduced to the state of a hydrate, but a well marked, solid carbonate, with only a thin surface coating of hydrate.

It will probably be found expedient to work it with either No. 1 or No. 3, or with both together, in order to obtain a good, soft pig metal.

No. 8. This ore is found in the upper band of the three already mentioned as occurring together in Mason's bed. It generally presents the appearance of nearly square blocks, or brick shaped masses, 7 inches thick. Above this ply of ore is a course of balls separated from it only by a few inches of friable sandstone ; a coarse quartzose grit lies a little higher. The aspect of this ore when it has not undergone any decomposition by atmospheric influences, is a dark gray color, a rather rough surface, and a mixture of shining metallic particles interspersed through the body of the ore, as well as on its surface.

Its specific gravity is 3.4783.

At 320° it loses, ...	0.4	per cent.
At white heat it undergoes decomposition and loses,	25.8	"
It smelts without difficulty, and yields of pig iron,	43.3	"
It contains of earthy impurities fusing into a dirty white cinder, ...	25.4	"
And the oxygen is, ...	5.1	"
	100.0	

The pig metal obtained was soft, grey and tough. There is no doubt in my mind that this ore will be found to work well either by itself or with the other ores found in this bed.

No. 9. This specimen was from the stratum of balls, three inches thick, in the above mentioned opening, not far from Mason's coal mines.

Its color is yellowish or dark brown.

Its specific gravity is 3.4977.

At 320° it loses, ...	0.5 per cent.
Calcined to whiteness, it loses in addition, ...	25.5 per cent.
And when smelted, yields of pig metal, ...	45.6 per cent.
Of earthy impurities it contains, ...	10.7 per cent.
And of oxygen, ...	17.7 per cent.
	100.0

This iron is moderately tough, and of a light color, appearing rather less favorable for foundry purposes than the results of the other plies in the same bed.

No. 10. This specimen, as well as the next, was found on Wagner's run, the precise elevation not ascertained. It appears in many respects analagous to the ore in the 37½ inch bed on Fall Creek, being a conglomerate of pebbly masses of clay ironstone, with a cement of earthy and ferruginous matter.

Its specific gravity is 2.823

It contains of water,	9.2	per cent.
It yields of pig metal,	29.8	"
It contains of earthy impurities,	50.	"
Oxygen,	11.	"
	100.	

No. 11. This specimen, as well as the preceding, was found in the channel of Wagner's run, but as there can be no doubt of its having belonged to a regular stratum of ore not yet explored, but of considerable thickness, it was deemed expedient to examine its properties.

Its specific gravity is 3.5065.

It yields 50 per cent. of pig metal, soft, gray, and tough. It resembles strongly the ores found in the bed of Long Valley creek, in some parts in large quantities, and also has a striking similarity to the upper ply in Mason's ore pit. It contains but 8 per cent. of matter insoluble in acids.

From the foregoing details it will be observed that the yield of the several ores is as follows, viz:

No. 1,	32.5
No. 2,	24.2
No. 3,	44.0
No. 4,	53.4
No. 5,	48.4
No. 6,	29.4
No. 7,	45.0
No. 8,	43.3
No. 9,	45.6
No. 10,	29.8
No. 11,	50.0

Mean 40.5 per cent.

Fireclay.

At least three strata of fireclay have been observed on the waters of Fall Creek; one 16 inches thick, under the 37½ inch bed of iron ore; one 4 feet thick, above the 10 feet bed of ore and iron shale; and another, still higher, accompanying a bed of ore under the coarse gritstone or conglomerate. This clay, of the 4 feet bed, has a dark gray color, compact structure, and possesses a specific gravity of 2.646. In the fire it becomes reddish white, but is otherwise unchanged except by cracking, as it shrinks, and displaying on the exterior some traces of oxide of iron.

Limestone.

A sample of the limestone picked up in the channel of Long Valley creek, possesses a specific gravity of 2.7054.

It contains about, ...	40.0	per cent. carbonate of lime.
	3.5	per cent. peroxide of iron.
	56.5	per cent. argillaceous matter.
	100.0	

As the valley of Towanda Creek, below its junction with the Carbon Creek, presents many localities where fossiliferous limestone of lower strata than that above described, are brought into view, it was deemed proper to make also some trials to determine its degree of purity; its color is reddish gray.

Its specific gravity is 2.658.

It yielded of carbonate of lime, ...	45.5	per cent.
It yielded of peroxide of iron, ...	5.5	"
It yielded of earthy argillaceous matter and sand, .	49.0	"
	100.0	

Report of J. T. Hodge.

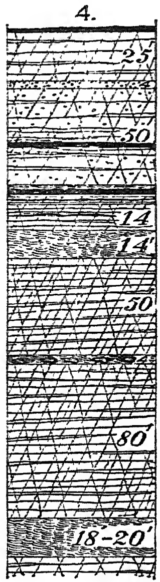
In 1841 the First Geological Survey of Pennsylvania examined and reported briefly upon the Barclay Coal Basin.* The report says:

"The east termination of the coal is upon the mountain between the South Branch and Carbon Creek; the west

* The work was done by Mr. Hodge; and is in the Final Report Vol. II pp. 512–513.

does not probably pass west of the township line of Franklin. Loose blocks of conglomerate are occasionally met with west of that line on the top of the mountain.

The following is a section of the measures at Fall Creek :



Coal,	—
Sandstone,	25′
Pea-conglomerate,	4′
Gray and yellowish S. S. (some layers coarse and somewhat pebbly, some with coal and charcoal,)	50′
Slate, with fern impressions,	2′
Coal,	3′
Slate, with Sigillaria,	1′
White Sandstone (with coaly matter and impressions,)	3′
Black Slate and Coal,	
White Sandstone, somewhat pebbly, with coaly matter,	14′
Ferruginous bluish and red shale position of upper ore bed,	14′
Yellowish gray fine grained argillaceous S. S.,	50′
Ferruginous shale, and massive mottled gray concretionary iron ore,	3′ 6″ to 4′
Yellowish gray fine grained argillaceous S. S.,	80′
Red Shale,	18′ to 20′
Sandstone,	—

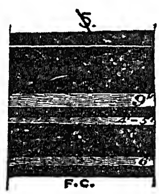
The upper or main bed has been worked at Mason's old mine, 4 miles above the mouth of Carbon Creek, and on the mountain between it and Towanda Creek, where it was found to measure in coal over 4 feet 7 inches; and also in several places at the old mines 5 miles further west, where it included, according to Mr. Johnson's report, from 5 to 7 feet of coal. The following section embraces the strata in the descending order displayed on the stream at Gatiss' coal mine :

Coal,	6′
Fireclay and sandstone,	20′ to 25′
White Pea Conglomerate (Seral,)	12′
Yellowish SS. and soft shale,	50′ to 60′
Shale and sandy marl,	16′
Umbral S. S. ?	—

Between 2½ and 3 miles west of the residence of Mr. Gatiss, the latter has opened a coal bed, and a deposit of

iron ore. The coal is 5 feet 9 inches thick, nearly without slate partings, and has a sandstone roof, and floor of fireclay. The fireclay is quite pure and exceeds 8 feet in thickness. The conglomerate is only 12 or 15 feet below the band of fireclay. It is about 12 feet thick and is underlaid by yellowish sandstone and soft shale. Iron ore was found over the Upper red shale and under the Umbral sandstone. It was not fully opened though as much as 12 feet of shale were cut and found full of balls of rough irregular concretionary ore. It is thought (by Mr. G.) to be a real stratum.

The following are the subdivisions of the coal at Gatiss's:



Coal, not mined, very bituminous,	8" to 0' 10"
Parting,	—
Coal,	2' 4"
Slate,	9"
Coal, (blacksmith's band,)	6"
Slate,	4" to 0' 5"
Coal, (suitable for grate,)	1' 8"
Slate,	6"
Coal,	6"
Fireclay,	—

Two or three species of Sigillaria are found in this coal.

A lower bed which, as the section shows, has been opened on Fall creek, measures about three feet of coal. This bed is the only one to be found on the mountain between Carbon creek, Middle Branch, and South Branch. The top of the mountain is capped by the Conglomerate, which forms upon it, as well as on all the other high parts of the ridge, a bold, white ledge, visible from a distance.

The Conglomerate here is quite coarse, often containing pebbles as large as filberts.

The iron ore under the upper bed lies in three bands, the upper of which yields the best ore. This is a close-grained carbonate, very similar to the ore of the coal measures in the western counties.

At the upper limit of the Vespertine sandstone series, we find on Carbon creek, and in other localities, a comparatively worthless stratum of red iron ore. This ore was opened by Mr. Johnson, on Fall creek, at a level of about 70 feet lower than the more valuable Umbral ore, which underlies the Conglomerate. Here it consisted merely of

silicious and argillaceous materials, cemented together by oxide of iron, with some ore balls intermixed. At other places it appears as a very ferruginous red sandstone."

Although the above reports were sufficient to establish the value of the Towanda coal basin, yet nothing could be done towards developing the region until the North Branch canal should be completed.

Work having been suspended upon this canal, the Barclay coal basin remained untouched until, in 1854, the State having, in the meantime, resumed work upon and almost finished the canal, the Barclay Coal Company prepared to build the necessary miles of railroad from Towanda to Barclay, and to develop the region extensively. Previous to such development, however, Prof. J. P. Lesley and Jos. Lesley made a complete report to the company, giving in detail the acreage of coal bed B. available, and all facts relating to the basin.

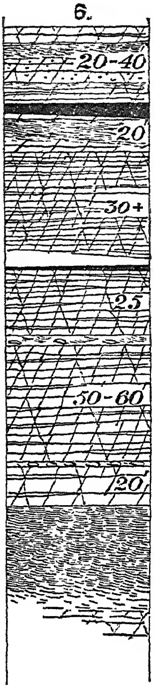
Report of J. P. and Jos. Lesley.

On the map accompanying this report, these areas of coal bed B. are all laid down; being taken chiefly from Prof. Lesley's original map. He reports the Schroeder Creek section thus:

"The vertical sections of coal, and the intermediate rocks, and the vertical profiles drawn upon the same sheet, with the map of the lands, express the order of superposition, and general character of the rocks."

1. On the top of all are softer sandstones and some shales, with a layer or two of very hard and sometimes pebbly rock. Twenty or thirty, and sometimes even forty, feet of these strata form the very highest broad, level summits between the ravines, which cut down southward through the property in the Schroeder. They form roundish, oblong, or dumb-bell shaped knolls and summits, with a disposition to fall off all around in a sloping bluff.

2. Under them lies the upper and large coal bed B, from 5½ to 9 feet thick. It outcrops all around the knobs or flat areas, before described, on the sides of the sloping bluffs, under the sandstones.



3. Below the coal spreads out a terrace of shale and sandstone rocks, say 20 feet thick, to the edge of a system of precipices formed by the ragged edges of the great conglomerate, as it has been improperly called, for its very characteristic feature is the absence of pebbles in a rock so massive.

4. Beneath it are flinty, thin-bedded sandstones, forming the precipices of Fall Creek and other ravines, and bluffs of various heights along the valley of the Schroeder. Thirty feet or so of these sand rocks, with no intermixture of shale, making in all an interval of about 80 feet between the upper and the lower coal beds, bring us down to the latter.

5. The lower coal bed, A, from 1 to 3½ feet thick, with a much more extended outcrop than the upper coal bed, but apparently inferior quality of coal.

6. Twenty-five feet, more or less, of similar flagstone rocks.

7. Four or five feet of shale and clay, with numerous nodules of carbonate of iron.

8. Fifty or sixty feet of flagstone rocks, as before.

9. This is a valuable stratum of gray carbonate of iron (100 feet below coal A) 3 feet thick (on Fall Creek), divided diagonally into large masses by, and reposing upon a variegated clay, of extreme fineness, like fuller's earth. Its tabular fragments pave the bed of the creek between the Falls, and are several feet in length. Its mining will be a very easy process, so long as it retains its character at the Falls. It undoubtedly spreads to a great extent, under the broad summits of the mountain. Johnson's analysis shows it to be a 33 per cent. ore (earth, 30 per cent.; oxygen, 14; water, 24). It interests the geologist to observe that it lies 70 feet above the upper limit of the upper red shale band (XI) and can be discovered elsewhere by that mark. With a proper application of skill and capital, the value of this stratum can hardly be exaggerated; and its present ap-

pearance would justify the erection of a furnace upon the Schroeder branch, where water power would never fail; and the immediate neighborhood of fuel and ore would compensate for the necessity of hauling the flux from a distance, provided a careful trial failed to show a sufficient amount of lime in any of the impure calcareous beds which make their appearance along the creek, below the great Falls.

10. Twenty feet of gray sandstone rocks.

11. Upper band of red shale, (Umbral), formation XI, of the Pennsylvania Reports. Forty-five feet of it are visible, constituting the lower half of the Upper great Fall. It is a marked feature in the geology of the mountain, and forms a steep slope upon the mountain sides of the Schroeder Valley. There is another band of red shale lower down, below which the Vespertine, gray, flaggy sandstones (X) set in for several hundred feet, and below these again, and occupying the whole lower portion of the valley of Schroeder, are the red shales and sandstones of the Old Red Sandstone, the Levant (of Rogers) the IX Formation of the Reports. They are the sandstones which make the rapids and falls of the Schroeder; and here occur the impure limestone layers alluded to in previous reports. Through all the above series of rocks, from 800 to 900 feet thick, not only the Valley of the Schroeder itself, but all the branch vales and ravines opening into it, are troughed down. Nothing can exceed the steepness of these ravines; their streams are a succession of cascades, but their head waters, flowing over the great plateau of sandstone which forms the summit of the mountain, are intercepted in their course, partly by the synclinal structure of the plateau itself, and partly by the innumerable fragments of rock, swept southward across it from its northern edge, overlooking the Towanda Creek.

These head waters spread out into wide, deep, ribbon shaped laurel-swamps, in which a deposit of first drift, then sand, and lastly vegetable mud, has been going on for an indefinite period. These long swamps, stretching north and south across the top of the mountain, sub-divide the

whole area of its summit into a series of coal patches, a continuation eastward of the series on the Barclay lands, next adjoining these on the west. * * * * *

The ground rises westwardly. The streams head up in that direction. The coal rises with them, and this has brought about the result, that all the central and western tracts on the property are wholly denuded of good coal, which can be traced but little beyond the Sunfish Pond on the John Boyd tract.

The lower coal bed, A, may underlie the surface as far as to the head waters of Rollison Run, but from the similarity of the rocks which enclose it, and its own thickness, it cannot without great effort be discovered, and will probably nowhere repay the expense of opening. It is this bed which no doubt furnishes reports of coal on Wolf Creek, Rollison's Run, and the heads of little Schroeder. No calcutions of moment can be based upon the expanse of this lowest coal (A). It has been sought after diligently along the eastern edge of the property, and not found, at least in working size. Where it has been fairly opened at the Falls, on Fall Creek, on the property adjoining to the east, it is a bony, sulphurous coal, not 3 feet thick. Such is its character in the counties further west where it has been preserved from denudation.

The principal bed, B, on the contrary, always affords a pretty good, and generally a superior coal. It is disposed to part into three main layers; the uppermost and middle layers are the best. In the boring (on the North Cox line) it is 10 feet thick, 7.5 of which is coal. Elsewhere it yields 6′ 10½″ of coal in 9′ 2″, and 6 feet of coal in 7′ 6″ of rock. In the new opening made on McKraney's Run, (on the east Joseph Henry line) it shows a solid breast of coal 5′ 9″ thick. Underneath it lies a valuable stratum of white fireclay into which we sank four feet without getting through.

At the old openings at Gatiss's, whence the wagons that visit the mountain get their supply, only three feet of the upper best coal is at present mined, but when efficient means are called for to supply a heavy trade, the whole or most

of the thickness of coal will be taken out. The excellency of its quality is already acknowledged. Blacksmiths value it because it is very free from sulphur, and makes a good hollow fire. In the stove it burns with a rich flame, and leaves little or no ash. Specimens of it from the old mine, and from openings made in it a mile to the eastward, were analyzed by W. R. Johnston, in 1840, and show the presence of only 12 to 15 per cent. of volatile matter. This ranks the coal among the semi-bituminous coals, which are peculiarly fitted for iron smelting and steam generating purposes. It is the same bed of coal which holds so high a reputation in the Broad Top region, and is, I think, quite equal to it in the quality of its fuel. It is also about the same average size with that. It is remarkable that, at so great a distance, this bed B should exhibit such uniformity of disposition. Even the small attendant seam above the Broad Top coal, appears on your property. At Gatiss's there is a small one foot coal bed, about ten feet over the bed B.

The *Iron Ores*, of which I will now speak, have an immense extension across your property. I picked up numerous specimens of the gray ore in the bed of the Big Schroeder, near the southwest boundary line. This is the ore which outcrops in an irregular stratum, three feet thick, beneath the third fall on Fall creek, one hundred feet below coal A, and two hundred feet below coal B. It is, by analysis, a thirty-three per cent. ore, and solid; included both above and below by fireclay, or soft, variegated shale. A drift, five feet high, would have rock top and bottom, clay drivage, and a three-feet plate of ore. It is not in any apparent connection with the true Red Shale formation, the top of which is 70 feet beneath it. All between consists of flag sandstones, as above. The top of the Red Shale is exposed for forty feet, without a sign of iron ore. This bed, therefore, is the representative of the ore of XI, of our Pennsylvania Geologists, traced by Mr. Hodge and myself, as far as the Virginia line.

To show its geographical extent, I refer to Mr. Hodge's Report to the State Geologist, condensed in the Fifth An-

nual Report, where the fact of two Red Shale formations, a hundred feet apart, is mentioned, and the ore described as a stratum six feet thick, one half ore, and four feet beneath the Conglomerate. And again, as a bed of shales from four and a half to six feet thick, the upper half richest in ore, which is nearly solid. It is described as a nodular, white, crystalline proto-carbonate, somewhat resembling a fine-grained sandstone. And again, as spathose or sparry, somewhat laminated, siliceous, gray. Analysis: Protoxide iron, 41.22; silica, &c., 28.80; carbonic acid, 24.00; water, 4.28; alum., 1.00; lime, 0.50.

This ore at Fall creek comes out in immense plates, which have been carried by the freshets a hundred yards below the outcrop, under the Fall. Some of these plates are eight and ten inches thick, and three or four feet long. They are crossed in all directions by sparry bands, showing a disposition in the mass to nodular structure. It is an ore of excellent quality, when compared with carbonates of the coal formation, and will afford, according to Overman, with charcoal and cold blast, an excellent forge iron. But none of the carbonates do well with the hot blast. They require great experience and care in the handling, and are profitable only when the proper skill and capital are expended upon them. They are the chief source of all the iron made in England and Scotland, and they must in time be our chief stand-by, and furnish most of the iron for future use in the United States.

The Gray Ore of Fall creek is likely to outcrop just above the Red Shale, on both sides of all the deeper valleys on the property, and at some future time will bear a value only secondary to that of the coal.

I found many masses of pyrolusite, a binoxide of *Manganese*, in the shingle of the Big Schroeder and its side ravines, and traced them to the foot of the falls, on the Rollison run, at a Barometric level of +370, or about eighty feet above the Schroeder, at the mouth of Rollison's run, and about 210 feet below the point at which line B crosses the upper part of the run. As the dip everywhere to the south of the Little Schroeder is towards the north or

N. N. West from 1° to 3°, I judge this stratum of Manganese to lie about four hundred feet (geologically) beneath the great Conglomerate stratum under coal B, and between the two Red Shale formations.

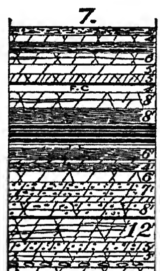
The size of the lumps was very uniform, and such as to induce the belief that the stratum from which they came was not over six or eight inches thick. The material is in extensive demand for the production of chlorine for the manufacture of bleaching powder, and for glass houses."

These very complete reports sufficiently established the value of the Barclay Coal Basin; and the Barclay Coal Company completed their railroad, 16 miles long, from their new village of Barclay (near Gatiss' mines) to Towanda.

This railroad was completed in time to be ready for business on the finishing up of work on the North Branch canal, and for twenty years the company has been shipping coal largely from their mines. Since 1872 the canal has been abandoned, and a new railroad along the North Branch of the Susquehanna river, the Pennsylvania and New York Canal and Railroad Company, is now the avenue by which the Barclay coal reaches its market.

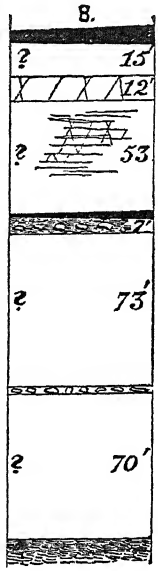
A boring made many years ago in the property of the Barclay Coal Company, (at the junction of the And. Grayson and Jac. Cox lines,) gives the following section of the measures from the surface down to and through coals B and A:

7.



Surface soil,			4′ 0″
Brownish grey S. S.,			4′
Slate,			2′
Slate *and Coal*,			3′
Hard brownish grey S. S.,			6′
Grey Sandstone,			5′
Grey Sandstone,			5′
Coal, small,			—
Fireclay,			4′
Grey Sandstone,			8′
Slate,			8′
Coal, B,	Slate,	1′ 0 ″	10′ 3″
	Coal,	1′ 9 1-2″	
	Slate,	0′ 10 ″	
	Coal,	0′ 5 1-2″	
	Slate,	5 ″	
	Coal,	2′ 0 ″	
	Slate,	1′ 0 ″	
	Coal,	1′ 11 1-4″	
	Slate,	9 3-4″	
Fireclay,			2′ 0″
Dark slates,			6′
Grey Sandstone,			2′
Grey shales,			4′
White Sandstone (hard, brown pebbles)			6′
Brown and white Conglomerate,			7′
Brown ferruginous sandstone,			3′
Grey conglomerate,			8′
Coal, small (A ?),			—
Gray and brown Sandstone,			12′
Hard grey brown Conglomerate,			5′
White Sandstone.			5′
Iron Ore ?			—
White Sandstone,			—

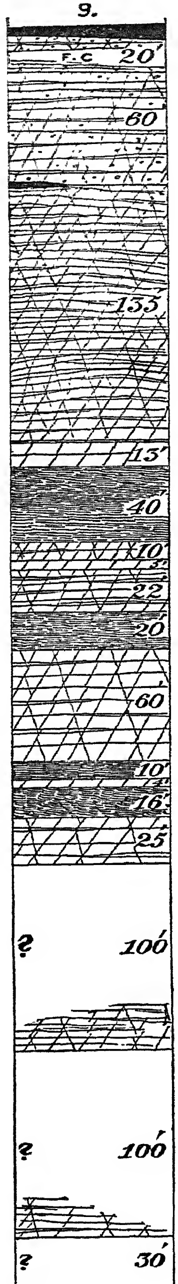
Another section of the measures holding coal beds A and B, made on Coal Run gave—



Coal, B,	—
Interval,	15′ 0″
Sandstone, massive,	12′ 0″
Interval, sandstone,	53′ 0″
Coal, A,	—
Shale, containing iron ore,	7′ 0″
Interval,	73′ 0″
Ore bed, 3′ thick,	—
Interval,	70′ 0″
Red shales,	—

The vertical section from coal bed B down to Schroeder Creek shows thus at the Barclay R. R. incline plane— .

9.



Coal B, ...	—
Fireclay and sandstone underlying, ...	20' 0"
S. S., Conglomerate, .	60'
Coal A, (place for, not opened)	—
S. S., brown to gray, and grayish white; much current bedded; no conglomerate layers showing, in places very ferruginous and friable, ...	135' 0"
Gray fireclay slate, . .	2' 0"
Red clay rock, massive,	13' 0"
Red and gray slate, . .	40' 0"
Gray sandstone, ...	10
Red clay rock, ...	5'
Gray sandstone, ...	22'
Red slate, ...	20'
Gray greenish S. S., . .	60'
Red slate, ...	10'
Micaceous sandstone, .	4'
Red shale, ...	16'
Gray sandstone, ...	25'
Interval, rocks not seen, but gray S. S. near bottom, ...	100'
Interval, rocks not seen, but gray S. S. near bottom, ...	100'
Interval, ...	30'
Foot of Plane, ...	—

Of the small coal bed 36 feet above coal bed B (see page 125, record of bore hole) nothing further can be said than the fact there given. It is reported as 3 feet thick; but this probably includes roof and parting slates, and cannot be depended on as a measurement.

A coal apparently overlying coal bed B by about the same interval distance was once opened in the crop over towards the eastern end of the basin. It was small, and gave no evidences of possessing value. These are the only two openings on it recorded.

It may be dismissed therefore as of unknown size and character in the Barclay basin, but with strong indications that it is small and worthless.

The small coal 20 feet above coal bed B is under a foot in size, and has no commercial value.

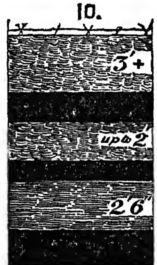
Coal Bed B is the bed which has given in the past and now gives its value to the Barclay Coal basin. The day will doubtless come when coal bed A will be worked at various points and much coal shipped from it; but at present, as in the past, all the coal going to market from the Barclay basin is yielded by coal bed B.

Coal is mined and shipped in large quantities from the Barclay Mines of the Barclay Railroad and Coal Company, and from the Schroeder Mines of the Carbon Run Coal Company.

Barclay.

At Mine No. 1 of the Barclay Mines, the coal measured

10.



Sandstone on top,	—
Roof slate,	3′ 0″ +
Coal, top bench,	1′ 6″
Slate,	—up to 2′ 0″
Coal,	1′ 0″ to 1′ 2″
Slate,	2′ 6″
Coal,	1′ 10″
Fire clay floor,	—

The coal in the lower bench is friable, columnar, deep black, free from slate.

The middle bench is friable, columnar, black.

The upper bench, cubical, harder, does not crumble, and has no regular slate layers.

This is one measurement; but the measurements given below, all made in the present mines of the Company, are taken from the notes of F. F. Lyon, Chief Engineer, and show the great variations in size to which the coal bed is subject:

Sandstone on top,	—
Slate roof,	10′ 0″
Coal,	5′
Fire clay floor,	—

There are no slate partings at this place, and yet the coal is clearly in three benches as before; the benches being defined, not by slate partings, but by the structure and appearance of the coal.

Another measurement gives—

Slate roof,	—
Coal,	1′ 9″
Slate,	8″
Bone coal,	6″
Coal,	8″
Slate,	6″
Coal,	2′ 6″
Fire clay floor,	—

And again:

Sandstone roof,	—
Coal,	1′ 6″
Slate.	1′ 0″
Coal,	2′ 0″

And again:

Sandstone roof,	—
Coal,	1′ 10″
Slate,	0′ 2″
Coal,	6″
Slate,	6″
Coal,	10″
Fire clay floor,	—

And again:

Slate roof,	—
Coal,	1′ 6″
Slate,	2′ 0″
Coal,	1′ 3″

Fire clay,	1′ 0″
Slate,	0′ to 6′ 0″
Coal,	2′ 9″

These variations are very great, and within comparatively short distances.

The roof varies equally rapidly; in Mine No. 1, there is entirely a slate roof; while in Mine No. 2, (close by) there is almost entirely a sandstone roof.

In working the Barclay mines they have passed through a disappearance and re-appearance of the bottom bench of Bed B which is so unusual in its features as to call for special comment.

The following letter from Mr. F. F. Lyon, Mining Engineer of the Towanda Coal Company, and the accompanying illustration, (Page Plate I,) will explain the case clearly.

Under date of Barclay, Nov. 2, 1877, Mr. Lyon writes thus:

"When you were here we were talking about the peculiarities of the coal basins of the State of Pennsylvania.

"We have just passed through one of those, and thinking perhaps that it might be of interest to you as a Geologist, I have endeavored, by a rough sketch, to show you something of its nature.

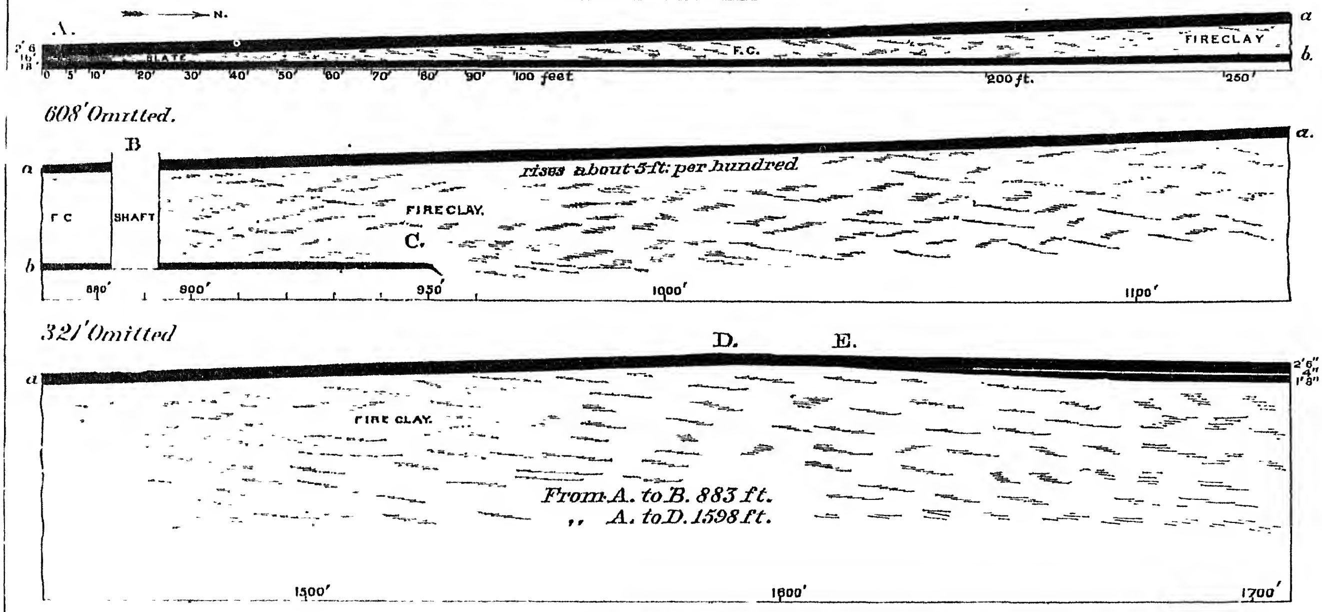
"At the point A on the sketch, you will observe that we have the vein lying perfectly natural, viz: bottom coal, 18 inches in thickness; top coal, 2 feet 6 inches in thickness, separated by 16 inches of slate, and all with a gradual raise to the north.

"At this point (A) the slate begins to thicken, and also to change from a slate to a very hard fireclay, so that when it reaches the point B, a distance of 883 feet, instead of having the 16 inches of slate, we have about 19½ feet of very hard fireclay, both seams of coal remaining the same, and retaining their full thickness; the bottom seam running, however, but about 40 feet further, when it begins to lessen, and in 30 feet further it wedges out entirely, and is lost in the heavy bed of fireclay, (at C,) the latter part dipping very rapidly.

"The top seam continues on, raising about 3 feet to the

Fig.11.

Isolated lengths of longitudinal Section to illustrate Variations in Barclay Coal Bed (B.) furnished by Mr F. F. Lyon.



100, with fireclay bottom, until it reaches the point D, a distance from A of 1,598 feet.

"At this point (D) the vein begins gradually to go to the dip, and at E, a distance of 25 feet, we first discovered signs of the slate and bottom coal returning, and in going about 100 feet, find the vein again as regular as at A, with the exception of the slate, which is considerably thinned, being but 4 inches in thickness."

This case of variation of parting thickness of seams of the same coal bed, the whole case being plainly in view, and all within a distance of less than 600 yards, is of interest in connection with the long-continued discussion on the parallelism or non-parallelism of coal beds; as it shows how readily imperfect facts may lead into erroneous conclusions.

For if, instead of one continuous mine opening, there were outcrop openings at A and E, and the shaft at B; the latter would of course show two coal beds, 20 feet apart, separated by fireclay, while A and E would show one coal bed with a slate layer, and no coal bed 20 feet below: the inference being that the lower coal bed had absolutely disappeared.

Without re-opening here the question of the parallelism of coals, it may be stated that in the work of the Second Survey of Pennsylvania there has been nothing developed as yet, (in the facts in the published reports,) which would call for any re-shaping of the conclusions reached by Prof. Rogers, and clearly stated in the Final Report of 1858, where he shows that while the normal condition of coal beds is one of parallelism, sometimes over very great areas, yet there are numerous instances of great local variation in interval distances, many such variations being pointed out as occurring in Pennsylvania.

Taking Coal Bed B, with all its variations, at the Barclay mines, and it averages about 5,000 tons to the acre, or $3\frac{1}{4}$ feet of clear coal.

A specimen of the upper bench of the coal yielded, on analysis, (McCreath):

(The coal is generally bright and crystalline, but has some thin, slaty seams of slaty coal. It is rather tender, and carries numerous thin partings of mineral charcoal:)

Water,	.730
Volatile matter,	17.220
Fixed carbon,	69.840
Sulphur,	.795
Ash,	11.415
	100.000
Coke, per cent.,	82.05
Color of ash,	Gray.

A specimen of the middle bench of the coal yielded, on analysis (McCreath):

(The coal is generally bright and columnar, with numerous bands of slaty coal. It carries considerable slate in thin seams, and also in lenticular masses:)

Water,	.760
Volatile matter,	16.405
Fixed Carbon,	62.172
Sulphur,	.613
Ash,	20.050
	100.000
Coke, per cent.,	82.835
Color of ash,	Gray, with yellow tinge.

A sample of the coal selected from the bright crystalline portion was analyzed separately:

Water,	.750
Volatile matter,	17.070
Fixed carbon,	71.969
Sulphur,	.661
Ash,	9.550
	100.000
Coke, per cent.,	82.18
Color of ash,	Gray.

A specimen of coal from the lower bench yielded, on analysis (McCreath):

(The coal is bright and columnar, also cannel-like and resinous. The crystalline coal is very tender, and carries numerous thin partings of minera charcoal. It has a bright, black lustre, and breaks with cubical fracture.)

Water,	.880
Volatile matter,	16.660
Fixed carbon,	73.257

Sulphur,	.643
Ash,	8.560
	100.000
Coke, per cent.,	82.460
Color of ash,	Gray.

Specimens of the bright crystalline columnar coal, and of the cannel-like coal, were analysed separately.

Crystalline Coal—(McCreath.)

Water,	.850
Volatile matter,	17.080
Fixed carbon,	75.939
Sulphur,	.681
Ash,	5.450
	100.000
Coke, per cent.,	82.07
Color of ash,	Gray.

Cannel-like Coal—(McCreath.)

Water,	.900
Volatile matter,	15.050
Fixed carbon,	71.396
Sulphur,	.544
Ash,	12.110
	100.000
Coke, per cent.,	84.05
Color of ash,	Gray.

The cannel-like coal yields a coke which is only slightly coherent.

An average specimen of the whole of Bed B, as mined at Barclay, representing the run of the mines, as shipped to market, yielded, on analysis (McCreath):

(The specimen consists of bright, tender columnar coal, seamed with mineral charcoal and some slate partings; and also of compact, resinous cannel-like coal, with conchoidal fracture.)

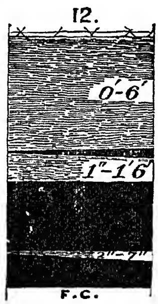
Water,	.770
Volatile matter,	17.110
Fixed carbon,	70.744
Sulphur,	.776
Ash,	10.600
	100.000

Coke, per cent.,	82.12
Color of ash,	Gray.
Sulphur left in coke,	.565
Per cent. sulphur in coke,	.688
Per cent. iron in coal,	.168
Sulphur taken up by iron,	.192
Free sulphur,	.584
Per cent. sulphur volatilized by coking,	27.190

Carbon Run.

The Schroeder Mines are opened on Coal bed B, about 1½ miles west of Barclay. A railroad from the head of the Barclay incline plane to the mines gives an outlet for the coal on to the Barclay RR.

Coal B as measured in the Schroeder Mine shows :



Sandstone roof,	—
Slate,	0 to 6′ 0′
Coal, upper,	1″ to 0′ 6″
Slate,	1″ to 1′ 6″
Coal, middle,	3′ 7″
Slate,	2″ to 0′ 7″
Coal, lower,	1′ 8″
Fire clay,	—

The upper bench is friable and columnar, irregular in size, of good character, and is the "blacksmith coal" of the mine.

The middle bench is harder and cubical in structure.

The lower bench is friable and columnar.

Specimens of the middle and lower benches yielded on analysis (McCreath):

"The specimens consist of bright crystalline columnar coal and grayish black cannel-like coal.

The middle (3′ 7″) bench yields :

Water,	.940
Volatile matter,	17.845
Fixed carbon,	72.155
Sulphur,	.670
Ash,	8.390
	100.000
Coke, per cent.,	81.225
Color of ash,	gray with yellow tinge.

The specimen from the bottom bench (1′ 8″) contained the more slaty coal. The bright coal is tender and is seamed with mineral charcoal and iron pyrites.

Water,	.850
Volatile matter,	16.755
Fixed carbon,	69.390
Sulphur,	.715
Ash,	12.290
	100.000
Coke per cent.,	82.495
Color of ash,	gray with yellow tinge.

The coal bed of the Schroeder Mines is about at its average maximum of size and character. It yields about 6,000 tons of coal to the acre. The mines ship steadily about 700 to 800 tons daily.

The Schroeder Mines are near the western end of the basin so far as coal bed B is concerned; the old "west opening," about ⅔ mile west of the Schroeder being the west outcrop of B. The bed is here rising to the west and does not come in beyond Sunfish lake, so far as could be determined by this examination.

Mines East of Barclay.

The Barclay Mines have been fully described.

To the east of the Barclay mines there are numerous trial openings on bed B, but no mines are opened for shipment to market.

An old opening on McKraney's Run showed:

Cover, massive sandstone,	20
Coal (nearly all solid coal,)	5′ 9″
Fire clay,	4′ 0″ +
Interval,	15
Massive sandstone, Conglomerate,	12′ 0″

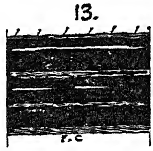
On the property 3 miles east of Barclay numerous test openings have been made on coal bed B. They show it in a natural condition, of good quality, and averaging over 3 feet of coal. Mr. Lyon made these test pits and states the facts as above. The pits are now closed.

At the extreme east end of the basin are the old *Mason Mines*, once quite important mines when coal was hauled

from there by wagons to supply a considerable region, the coal going up into New York State.

Though not now worked, yet the coal bed could be examined at these mines and showed—

13.



Roof, massive sandstone,	—
Coal, bony,	0′ 1 1-2″
Coal, some slate,	1′ 7 1-2″
Slate (and coal),	3 ″
Coal, some slate,	1′ 4 ″
Slate and bone,	2 ″
Coal,	1′ 0 ″
Black slate,	4 ″
Fireclay.	—

And again it measured—

Roof, massive sandstone,	—
Coal, bony,	0′ $1\frac{1}{2}$″
Coal, some slate,	1′ 3 ″
Slate,	3 ″
Coal, some slate,	3′ 0 ″

The sandstone roof is firm and regular, and the coal comes out close to the outcrop as firm hard coal. But in both openings the solid coal layers are intermixed with fine layers of slate, too small to be separable in mining, and which must add largely to the percentage of ash in the coal, and very materially injure it in competition with mines where the bed is purer.

The old *Northrop Mine*, also on bed B, not far from the Mason Mine, is now fallen entirely shut; it shows the same massive sandstone roof, filled with Lepidodendron impressions.

About 125 yards south southeast of the Northrop Mine, and 14 feet lower than it on level, a coal bed is opened up in a shallow pit on a flat. It looks much like a break off from bed B, though the Coal shows differently. The pit shows:

Surface,	1′ 0″
Yellow slates,	1′ 5″
Coal,	5′
Slate,	3″
Coal,	2″
Slate,	1′ 0″
Coal,	3″ to 6″
Slate,	3″
Coal,	3″
Slate,	1′ 10″

Coal,	4″
Slate,	5″
Coal,	0′ 2″
Slate in bottom,	—

This worthless mass of coal and slate is nowhere else found under bed B in the basin ; so it is most probably a slip down on that bed.

At *Anderson's House*, in the cellar, a coal showing 2 feet thick, was struck in the outcrop. Only loose stuff was overlying, and in the absence of any solid rock in place it is doubtful if the full thickness of the bed was visible at this place.

An old exposure, 200 yards south of Anderson's House, shows a coal, with massive sandstone roof.

And 300 yards further south there is an old opening now fallen shut. No measurements could be made in any of these openings.

South of the Schroeder Creek.

At the eastern end of the Barclay Coal Basin, west of Lamoka Station on the Barclay Railroad, the hills on the south side of the Schroeder rise somewhat higher than those on the north side, or rather the first abrupt rise is greater.

The summit of this high and narrow ridge apparently takes in coal bed B over a limited area. What this area is cannot be exactly stated without running out the outcrop lines. As plotted roughly on a property map the area is small, and much of that would be crop coal.

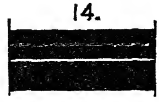
The openings and borings into bed B as made in the region south of the Schroeder are thus given by F. F. Lyon, the engineer in charge of the work.

"That bed B is 1925 feet above tide on the south of the Schroeder; while at the Mason Mine on the north side it is 1880 feet above tide; showing the rise of the coal to the pointing out of the basin.

That the cover over the coal averages 40 feet.

That on boring down the bed was found thus:

14.



Coal,	0′ 8″
Slate,	0′ 3″
Coal,	0′ 7″
Slate,	0′ 2″
Coal,	1′ 6″

And that a second boring found the same thickness of coal and parting slates."

These figures are given exactly as reported by Mr. Lyon. This report therefore confines itself to the statement that there is apparently a small area of bed B south of the Schroeder, opposite the Mason Mine; the area and the quality of the coal, as well as the average thickness being easily determinable at any time when such facts may be needed.

It will be noticed from the facts already given that coal bed B is of larger size and cleaner from slate in the western half of the basin; and while it varies much at all points in size and character yet the average condition of the bed at the Schroeder Mines, and the Barclay Mines, is certainly superior to the average condition, (taking in both size and character,) as developed by the test openings to the east of those points.

Subject to local variation this may be broadly stated as the condition of the bed in the Barclay basin.

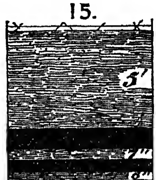
Coal Bed A in the Barclay Basin.

Between Coal bed B and Coal bed A the rocks are usually sandstone; the upper 12 feet (directly under the fireclay floor 4+ feet thick) being made up of massive sandstone, not always conglomerate but frequently so; while the sandstone from there on down to bed A is almost invariably filled to some extent with layers of pebbles.

The coal A has been opened in many places, but has been nowhere mined for shipment to market.

Where opened on *Fall Creek* it showed:

15.



Sandstone overlying,	—
Sandy black slate,	5′ 0″
Coal,	1′
Slate,	7″
Coal,	8″
Slate,	6″
Fireclay floor,	—

A specimen of this coal was forwarded to Harrisburg for analysis and yielded (McCreath):

(The coal is very compact, with dull resinous lustre. It breaks with conchoidal fracture and has the general appearance of a cannel coal.)

Water,	.850
Volatile matter,	16.625
Fixed carbon,	67.292
Sulphur,	.498
Ash,	14.735
	100.000
Coke, per cent.,	82.525
Color of ash,	Gray.

The coal yields a coke which is only slightly coherent.

Coal bed A has been opened repeatedly for measurement in the region east of Barclay.

It is reported as having shown from 2½ to 3 feet of good coal in these numerous trial pits. They were made for a special examination, and are all now closed.

A trial opening, on *Cash Run*, near the eastern end of the basin, on bed A, is reported to have found 3 feet of coal. It could not be seen or measured. The measures there are:

Sandstone, massive,	10′ to 20′
Clay slates, dark colored,	5′ to 6′
Coal, bed A, reported 3 feet thick, with one small slate parting.	

Wherever this coal bed A reaches 2½ to 3 feet in thickness it will prove a very valuable deposit. It is of good character; spreads over a broad area; lies well for mining; and is, for the greater part, as accessible as coal bed B.

No openings have ever been made upon it on the south side of the Schroeder creek, nor on any of the detached hill tops where it may have caught west of the Schroeder mines.

Iron Ores.

The Iron Ores of the Barclay Coal Basin have been fully described in the report of Prof. W. R. Johnson. (See p. 115 of this volume.)

The ore below coal bed A on Fall creek shows thus:

Coal bed A,	—
Fireclay,	—
Sandstone,	35′ 0″
Clay, gray,	2′ 6″
Clay, iron stained,	2′ 0″
"Ore,"	4′ 0″
Sandstone	—

The ore is only a very ferruginous clay, carrying an un-

usually large percentage of iron; but would be totally worthless as an iron ore.

At a distance of 150 feet below coal bed B, where it shows at the west opening of the Schroeder mines, there is an exposure of 10 feet of red slate. It is rich red in color, averaging probably 10 per cent. to 12 per cent. of metallic iron, and has always been called an iron ore.

It can possess no commercial value.

The proto-carbonate iron ores which were opened by Prof. Johnson for measurement and analysis are now closed up, and his records can be accepted as fair and reliable for all facts stated in his report.

Character of the Barclay coal.

The following table shows the analyses of the coals from the Schroeder mines and from the Barclay mines, conveniently grouped for comparison:

	Bed B, Barclay.				Bed B, Schroeder.		Bed A, Fall Creek.
	Upper bench.	Middle bench.	Lower bench.	Average.	Middle bench.	Lower bench.	
Water,	.730	.760	.880	.770	.940	.850	.850
Volatile matter.	17.220	16.405	16.660	17.110	17.845	16.755	16.625
Fixed Carbon,	69.840	62.172	73.237	70.744	72.155	69.390	67.292
Sulphur,	.795	.613	.643	.776	.670	.715	.498
Ash,	11.415	20.050	8.560	10.600	8.390	12.290	14.735
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke per cent.,	82.05	82.835	82.46	82.12	81.215	82.495	82.525
Color of Ash,	Gray.	Gray, yellow tinge.	Gray.	Gray.	Gray, yellow tinge.	Gray, yellow tinge.	Gray.

An average of six analyses of coal from bed B at Barclay and Schroeder Mines, gives the following result:

Water,	.822
Volatile matter,	16.999
Fixed carbon,	69.593
Sulphur,	.702
Ash,	11.884
	100.000

Leaving out the impurities, and counting only ignitible constituents, we have:

Carbon,	80.369
Volatile matter,	19.361
	100.000

And the relationship of volatile hydro-carbon to fixed carbon, 1 to 4.0939.

The Barclay coal is therefore a true semi-bituminous coal. Nearly all the coal produced from the basin is used for generating steam on the locomotives of the New York and Erie Railway, and the New York Central Railway, or on their connecting roads; but it is an admirably strong and efficient fuel for all purposes for which semi-bituminous coal is used.

Barclay Coal Production.

The following statistics of the coal trade of the Barclay coal basin from 1857–1877, are furnished by H. Shaw, Treasurer of the Barclay Coal Company.

There has been transported over the Barclay Railroad, from the Barclay Coal Basin, in Bradford county, from the opening of the road in 1857 to 1877, inclusive:

1857 to 1867,	559,588	tons.
1868,	73,901	"
1869,	180,726	"
1870,	273,335	"
1871,	378,334	"
1872,	382,843	"
1873,	337,394	"
1874,	337,389	"
1875,	373,719	"
1876,	383,984	"
1877,	362,652	"
	3,643,865	"

Of semi-bituminous coal produced from the following mines, viz:

Barclay Coal Company,	2,165,063	tons.
Schroeder Coal Company,	626,508	"
Fall Creek Coal Company,	525,186	"
Towanda Coal Company,	327,108	"

Chapter XII.

The Blossburg Coal Basin in Tioga County.

The Blossburg Coal Basin is a canoe shaped synclinal basin, remarkably symmetrical, extending from a point just beyond Fall Brook on the east, to and beyond the Bache Mine on the west side of Wilson's Creek.

The general strike is about North 19° E. and South 19° West.

The basin begins on the east with the region lying north of the Fall Brook Company, and known as the "Ward Lands." This large property, over 3,000 acres, has never been opened for shipment to market; but from reports of Messrs. Coryell, Lyman and others it is clearly, in part at least, in the producing measures of the coal basin.

Next to the south and west is the Fall Brook Company, with its extensive mines and improvements at Fall Brook.

West of this the Morris Run Mines and Village.

Blossburg village comes next; it is not now a shipping place for any coal mined close to the village; the last shipment over the plane having been about 1857.

West of Blossburg is Arnot, the seat of the mines and improvements of the Blossburg Coal Company.

West of Arnot is Antrim, where the Fall Brook Coal Company have a large and complete plant.

West of Wilson's Creek there are only a few country mines, and the basin is rising out to a canoe shaped point; this latter being probably not more than a few miles west of Wilson's Creek.

Along the length of the Blossburg Basin, a distance of about twenty miles, in an air line, the width of the basin varies somewhat, averaging say three miles.

The illustration (Page Plate II) representing a cross section of the Basin at Arnot, from side to side, looking west, shows the Conglomerate rim of the basin on its North and South side, how the North outcrop is 120 feet higher than the South outcrop, and how much the centre of the basin is below the outcrop on the North side.

In fact in all its geological features the Blossburg basin displays a singular symmetry.

In all synclinals it may be said to be the normal condition of affairs for subordinate cross rolls to interfere locally with the general harmony of the basin. But in this region a ruler laid upon the map will strike with its edge on a straight line close to Fall Brook, at Morris Run, at Blossburg, at Arnot and at Antrim. These are the lowest points in the basin, all of them at the true centre of the synclinal, and they are almost in a dead straight line.*

Of the general features of the basin but little need be said. Broadly speaking the enclosing mountains are capped by the massive Conglomerate of XII; on their outer sides, away from the basin, are steep slopes of XI, X and IX, down to the deeply cut surrounding valleys; while on the inside of the basin are hills of less height, though equally rugged, made up of the Lower Productive Coal Measures, which here contain so much massive sandstone as to cover nearly every hill slope with rocky masses, and make the surface wild and barren.

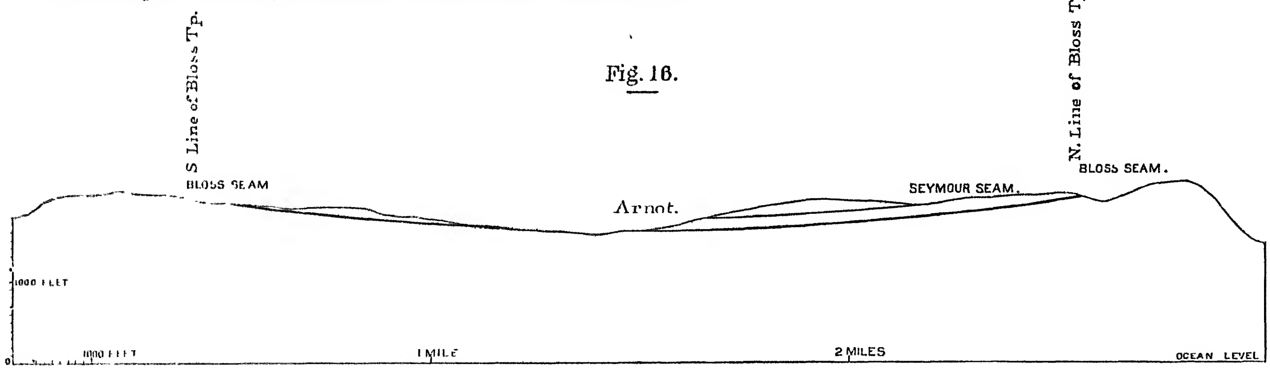
The cutting streams are the important feature of the Basin.

On the Eastern side of the Basin the different streams which drain that part unite near Blossburg and flow north, by the Tioga River, into the North Branch Susquehanna, or Chemung, at Corning, New York; and on the Western side the basin is drained by the equally deep cutting Babb's Creek, or Second Fork of Pine Creek, and by Wilson

* Morris Run is 1678′ above tide.
Arnot is 1682′ above tide.
Antrim is 1672 above tide.
These are at the centre of the synclinal, and are on a straight line.
Fall Brook is not at the centre of the synclinal, and is out of line. It is 1842 feet above tide.

Section across the Coal basin at Arnot in Tioga County, looking westward; showing the main or "Bloss Seam," bed B, outcropping at the North Bloss township line, 412' above its outcrop in the centre of the synclinal at Arnot; and showing also bed C lying 154' above the Bloss bed, B. Published by permission from a drawing made for the Blossburg Coal Company, by S. B. Elliott, Manager.

Fig. 16.



Creek, a branch of Babb's Creek; these Pine Creek waters reach the West Branch Susquehanna below Lock Haven in Clinton County, Pennsylvania.

The draining streams of the basin represent an enormous destruction of coal area, which destruction is of course always greatest where the coals lie as these do near the hill tops; but they afford an easy and economical outlet for almost every acre of coal land left in the basin. They enable the loaded trains to have always down grade; the up-grade against the empty cars.

Geographically the Blossburg Basin occupies a commanding position for the cheap supply of soft coal to the markets of New York State. There is ample railroad communication, in fact rather more than the annual shipment would at present seem to call for.

The Fall Brook Coal Company own their track from the Fall Brook Mines to Blossburg; the coal then goes over the Tioga Railroad to Lawrenceville; and over the Corning, Cowanesque and Antrim Railroad to Corning, and beyond.

The Morris Run Coal Company have their own track from the mines to Blossburg; from that place this coal goes by the same route as the Fall Brook Company.

The Blossburg Coal Company have their road from the mines to Blossburg; and also the Tioga Railroad from Blossburg to Elmira, New York. This railroad connects at Lawrenceville with the Corning, Cowanesque and Antrim Railroad, and is as above stated the line by which the Fall Brook and Morris Run Companies reach the C., C. and A. R. R.

The most important single outlet is the Corning, Cowanesque and Antrim Railroad. This is under the same control and management as the Fall Brook Coal Company.

The railroad starts at Antrim, runs to Corning, New York, (via Lawrenceville, where it receives the coal of the Fall Brook and Morris Run, both of them under this same management;) from Corning the same railroad, (under the name of the Corning, Geneva, and Syracuse Railroad,) carries the coal freights north, delivering them finally on to

the New York Central Railroad, and thus with connections reaching all points in New York, on the lakes, or in Canada.

The railroad distances to put the Blossburg Coal upon the line of the New York and Erie Railroad at Corning are as follows:

Fall Brook to Corning,	. . . .	48 miles.
Morris Run "	. . . .	45 "
Arnot "	. . . .	45 "
Antrim "	. . . .	52 "

And the distance from—

Arnot to Elmira is . . . . 49 miles

DETAILED REPORT.

Although the existence of coal beds near Blossburg has long been known, no systematic attempt was ever made to ascertain the thickness and character of the coal and iron ore beds until the year 1832, when Richard C. Taylor laid out the route of the railroad from Blossburg to the New York State Line and at the same time examined the mineral resources of the Blossburg Basin.

Report of R. C. Taylor.

Mr. Taylor's Report, published in 1833, contains eight detailed vertical geological sections; none of them absolutely complete, but yet having in them many facts, not now re-obtainable except by special opening for the purpose, concerning the carbonate iron ores of the basin.

The vertical sections are:

1. East Creek.
2. Bear Creek.
3. Coal Run.
4. Morris Run.
5. Boon Creek.
6. Johnson Creek
7. Tioga Valley.
8. Fellow's Creek.

1. East Creek Section.

1. Ground partially examined, consisting of sandstone, black slate, and shale, with traces of coal beds, . .	150′
2. *First coal vein*, ...	} 20′
3. Black slate and fire clay, ...	}
4. Sandstone shelf, ...	}

5. *Second vein of coal.*
6. Black shale, ... 36′
7. *Third vein of coal.*
8. Black slate, Deer Lick, ... 6′
9. *Fourth*, or three feet vein of *soft coal*, like Clement's coal, ... 3′
10. Black slate, fire clay, and hard shale, ... 9′
11. *Fifth vein of soft coal.*
12. Black shale, ... 5′
13. *Sixth, cannel coal*, thickness not proved.
14. Hard black slate, floor of coal vein.
15. Hard sandstone rock a fall of ten feet on the creek. Dip of the strata, south, ... 10′
16. Sandstone rocks, obscured with alluvium, ... 34′
17. *Coal* and fire clay, estimated position.
18. Sliding bank, ... 108′
    Concealed to forks of creek, ... 144′
19., 20. Sandstone series of rocks obscured by alluvium. ——
    Total, ... 525′

NOTE.—No coal has been raised in this valley at present. The only proved vein at the outcrop is the third vein in this section.

It may be remarked, that so far as it is possible to form a comparison, the main body of the coal in this valley is 120 feet above that on Bear Creek and Coal Run.

There appear indications of coal as high as from 530 to 550 above the Tioga in this section.

The base of this section at the confluence of East Creek and the Tioga River, is 65.82 feet below Blossburg, and 31 feet below the base of Bear Creek section.

2. *Bear Creek Section.*

1. From summit of mountain flat the strata consist of sandstone, with numerous vegetable impressions belonging to the Coal Measures, and traces of slaty coal in the gullies. Estimated thickness at this point, at $1\frac{1}{4}$ miles up the creek, ... 50′ 0″
2. *Highest coal vein*, obscurely traced, 470 feet above the Tioga River, ... doubtful.
3. Thin sandstone lamina, with abundance of impressions of coal plants. Fragments of coal slate washed down the gullies, . . 50′ 0″
4. Course of good argillaceous *ball iron ore*, weight, 201 pounds per cubic foot; also, some cores of weak, sandy ore in the run.
5. Coal, sandstone, slate, micaceous sandstone, in thin beds, vegetable impressions, mineral springs, . . . 50′ 0″

6. *Second coal vein*, its thickness not proved, 370 feet above Tioga River, 330.02 feet above Blossburg,	
7. Argillaceous slate and shale,	15′ 1″
8. Fire clay,	
9. Slate, with courses of balls of good *iron ore*,	
10. *Third coal vein*, the thickness is not yet ascertained.	
11. Argillaceous slate,	7′ 11″
12. *Fourth coal vein* of uncertain thickness, 307.02 feet above Blossburg,	
13. Argillaceous shale and slate beds, Several courses of good argillaceous *iron ore* in balls, Slaty rock and blue shale.	22′ 9″
14. *Fifth coal vein*, called Clement's coal, of excellent bituminous quality, worked about 30 yards under the hill, 321 feet above the Tioga, 281.05 feet above Blossburg,	3′ 3″
15. Black shale and occasional rock,	8′ 0″
16. *Sixth coal vein*, called Bloss' Vein, now worked 269.80 feet above Blossburg,	3′ 3″
17. Hard compact sandstone and slate, but varying in different points,	1′ 9″
18. Rock, variable,	12′ 0″
19. *Seventh coal vein*, not yet proved,	doubtful.
20. Sandy, weak ore, in coarse oval masses and concretions —ground partially examined—for the most part consisting of gray laminated sandstone, and shale occasionally, probably containing coal and iron ore,	44′ 0″
21. *Eighth coal bed*, not yet proved.	
22. Sandstone, shale, and slate beds, estimated aggregate thickness,	20′ 0″
23. Good fire clay, thickness not proved, 192.05 feet above Blossburg,	
24. Clay slate,	15′ 0″
25. *Ninth vein of coal*, not proved,	
26. Slate,	98′ 11″
27. Variable beds of sandstone, not explored,	
28. Strata, obscured by alluvium, and by large blocks of grit stone, millstone, or pudding stone, Some weak sandy ore occurs near the bottom,	75′ 10″
29. Unexplored ground, chiefly soft, slaty rock, and micaceous sandstone beds,	37′ 5″
30. Courses of small ironstone balls, in loose argillaceous rock,	5′ 0″
Total vertical section, from the summit of Bear Hill, at $1\frac{1}{4}$ miles up the Creek, to its junction with the Tioga River,	523′ 0″

The heights in feet above Blossburg in this and the following sections, are leveled from a point at Blossburg Bridge.

NOTE.—The chief supply of coal for the neighboring country has heretofore been taken from the 5th vein, No. 14. A lower vein of good quality has been recently opened.

The intersection of the principal coal beds in this ravine occurs at the distance of 1½ miles, in nearly a straight line west from Blossburg Furnace.

Height of the highest coal bed discovered, 470 feet.

Height of the highest ore bed, 420 feet.

Towards the summit a considerable inclination of the strata occurs to the south and south-east, probably to the amount of 80 to 100 feet in a mile; nearer the base the beds are more horizontal.

3. Coal Run Section.

Height of Coal run, or table land, one and a half miles above coal openings.

1.	Series of soft sandstone beds, indicative of coal. Thickness from the summit of mountain, opposite to the first or highest trial for coal, to that bed, by leveling,	128′	0″
2.	Blue clay slate, with vegetable impressions therein, .	3′	0″
3.	*First coal vein;* thickness uncertain at the outcrop.		
4.	Coal measures, with nodules of iron ore, ...	6′	0″
5.	Course of balls of *iron ore* in clay and shale, with impressions of ferns and reeds, 1.8′ to 2.8′, ...	2′	0″
6.	*Second coal vein,* showing 2′ at the outcrop, ...	2′	0′
7.	Argillaceous shale and clay, ...	4′	0″
8.	Dark blue sandy clay rock, having vegetable impressions and specks of mica therein, ...	6′	0″
9.	*Third coal vein,* not proved; at the outcrop only, . .	2′	0″
10.	Horizontal beds of clay and shale, ...	13′	5″
11.	*Fourth coal vein,* showing 18 inches face at the outcrop (this is probably the vein No. 10 in Bear creek—there 3.25 feet,)	1′	6″
12.	Bed of good fireclay, ...	2′	6″
13.	Dark laminated shale, ...	4′	0″
14.	Balls of *iron ore* in shale, occasionally very large, . .	2′	10″
15.	*Fifth coal vein,* now worked, from . . . . . . 3′ 7″ to	3′	11″
16.	Bed of *fireclay,* dug with the coal, ...	2′	7″
17.	Argillaceous shale with occasional nodules of *iron ore,*	10′	1″
18.	Vein of *rock iron stone,* worked out a few feet on trial,	1′	4″
19.	Compact sandstone rock, ...	10′	4″
20.	Second vein of *rock iron ore,*	1′	0″
21.	Hard irregular sandstone, traversed by numerous thin seams of coal and vegetable impressions, ...	11′	7″
22.	*Sixth coal vein,* worked about 20 feet, divided by a seam of hard black slate 10 inches thick, ...	2′	8″
23.	Blue shaly argillaceous rock, ... Horizontal beds of gray slaty sandstone, ... Good compact building stone, ...	24′	7″

24. Course of nodules of *iron ore*, in blue clay, ...	2′	0″
25. Bed of *fireclay*, ...	3′	0″
26. *Seventh coal vein*, very pure and highly inflammable, 1 to 2 feet thick, but has not been pursued, ...	1′	0″
27. Course of *iron ore*, called pins or kidney shaped nodules, ...	1′	6″
28. Beds of shale and slate, irregularly disposed with occasional ironstone nodules, ...	22′	4″
29. *Eighth coal vein*, called cannel coal, not worked or examined, say, ...	2′	0″
30. Sandstone rocks and unexplored ground, down to level of springs, which probably issue from some mineral bed, ...	32′	6″
31. Unexamined ground, covered with alluvium and siliceous blocks; it consists chiefly of sandstone rocks like the preceding, ...	44′	4″
32. A thick bed or deposit of red, semi-indurated clay, containing a considerable weight of oxide of iron, . . .	45′	8″
33. Continuation of similar ferruginous clay, altogether about 100 feet thick, as exposed on the slopes of the hill, ...	41′	10″
34. Lower part obscured by alluvial clay and stones, . .	10′	8″
35. Bed of weak, sandy, nodular iron ore, under the furnace, ...	2′	0″
36. Thence to the low water surface of the Tioga river, opposite to the iron furnace at Blossburg, ...	1′	1″
Total vertical elevation above the Tioga river, ...	455′	3″

NOTE.—Coal traces at this elevation of 500 feet above Blossburg Bridge; the ground rises beyond, 100 to 200 feet.

A considerable quantity of coal for the supply of the neighborhood has been taken from the colliery worked in the vein No. 5.

About 350 tons of the iron ore has been collected from the Bed No. 27, and is in readiness for smelting.

No other ore in the different beds in any of the sections has yet been raised.

The highest explored coal vein in this section is 320 feet vertical above the Furnace, and it is seven-eighths of a mile distance to the intersection of that vein on Coal Run; consequently the inclination of the plane is 36.5 feet per mile.

4. Morris Run Section.

1. Estimated height of strata belonging to the Coal formation, 600 feet.

2. [Concealed measures,]	140′	0″
Coal veins at least one mile above the big vein.		

3.	[Concealed measures,]	50′	0″
	Shale and mineral beds unexplored.		
4.	[Concealed measures,]	30′	0″
	Coal vein, not proved.		
5.	Slaty rock and dark blue clay stone,	9′	0″
6.	Five or six courses of rich argillaceous ball ore, in large oblong masses,	5′	0″
7.	Black shale,	22′	0″
8.	Courses of good iron ore.		
9.	Black shale and slaty rock,	21′	0′
10.	Fireclay,	1′	0″
11.	Big vein of coal, clear thickness of upper part, 5′ 11″ Small seam of slate, 0′ 2″ Lower part of the vein, 0′ 7″	6′	8″
12.	Blue argillaceous shale,	7′	7″
13.	Coal vein, thickness not proved.		
14.	Yellow sandstone in thin beds.		
	The "Devil's Punchbowl,"	9′	0″
15.	Thin ledges of sandstone; head of the Falls.		
16.	Stratified bed of millstone grit, or pudding stone, in the bed of the creek traversed, 164 yards long, falls 18 feet,	16	0″
17.	Sandstone ledges at Falls,	51′	6″
	Strong mineral spring 5′ above bottom layer.		
	Two mineral springs on bottom layer.		
18.	Sandstone ledges, dipping S. and W.,	12′	6″
19.	[Concealed measures,]	17′	0″
	Traces of soft coal and of ore washed down the run.		
20.	[Concealed measures,]	16′	6″
	Masses of iron ore loose.		
21.	Sandstone beds or ledges dipping N. in creek.		
22.	Ledges of brown or ferruginous sandstone dipping North,	42′	0″
23.	Ferruginous sandstone,	67′	0″
	Mineral spring 35 feet above bottom of layer.		
24.	Siliceous ore in large balls, washed, about	10′	0″
25.	[Concealed measures,]	20′	0″
	Clay deposit, and masses of ore 30′ to 60′,	60′	0″
	Total of this section,	613′	9″

NOTE.—The only bed which has been examined in this section, is the big vein. No road at present exists to communicate with this valley.

A ravine which descends into this valley from the east, intersects both coal and iron beds.

5. Boon's Creek Section.

Commencing on the Mountain Flat.

1.	Sandstone beds appertaining to the coal series about 50 feet to the upper or first coal vein,	50′	0″

2. *First coal vein*, thickness uncertain and not explored, 3. Argillaceous shale, with traces of *iron ore*,	15′	0″
4. *Second coal bed*, apparently a thick bed, 5. *Fireclay*, a thick bed, 6. Shaly argillaceous rock,	14′	0″
7. *Third coal vein*, below the narrows, 8. Several courses of good strong iron ore in balls,	7′	6″
9. Rock or shale, uncertain.		
10. *Fourth coal vein*, of good quality, formerly opened by Mr. Bloss, and discontinued since the discovery of coal in more convenient situations,	8′	8″
11. Soft blue shale, 12. *Fifth coal vein*, also formerly opened by Mr. Bloss, of good quality,	9′	7″
13. Blue shale,	3′	0″
14. Fireclay,	2′	0″
15. Sandstone rock and slate,	20′	3″
16. Compact sandstone and building stone to the head of the falls, probably a continuation of bed No. 23 in the Coal Run section, and in No. 12 of East Creek section,	16′	6″
17, Hard compact sandstone beds to the foot of the falls,	31′	3″
18. Various strata of sandstone, partially exposed; but for the most part concealed by very large masses and blocks of siliceous grit and pudding stone, extending down to the level of the Tioga River, about 200 feet lower. Many of these fragments, which have evidently sunk from a much higher elevation, contain more than a thousand cubic feet each,	200′	0″
Total of the section in vertical height above the Tioga River at Blossburg,	379′	9″

NOTE.—The intersection of the upper coal beds in this ravine is at the distance of $1\frac{1}{2}$ miles in a straight line west from Blossburg Furnace.

Inclination 252 feet per mile.

6. Johnson Creek Section.

The intervals between, and the respective thicknesses of the different strata, are for the greater part by estimation only in this section.

The present section commences at 5 miles S. W. of Blossburg.

Bed of bog ore near the summit 3′ thick.

First coal bed from 50 to 70 feet above No. 3.

1. Grey shale and slate, with indications of coal, may be traced toward the upper part of the creek, and continues to a strong ferruginous spring, with appearances of bog ore.		
2. Courses of good *iron ore*, in flat masses, bedded in shale and slate, ...	2′	0″
3. *Second coal vein*, showing a face of 18 inches in the bank of the creek, ...	1′	6″
4. *Fireclay*, about 18 inches, ...	1′	6″
5. Alternate beds of shale or slate and clay, with nodules of iron ore interspersed, estimated at	10′	0″
6. Fireclay, ...	1′	6″
7. *Third coal vein*, about 18 inches face, in the bank, . .	1′	6″
8. Soft rotten slate, ...	2′	0″
9. Thick bed of *argillaceous* iron ore, occurring in masses, both as veins and balls, ...	3′	0″
10. Slate as before extending to another or two courses of good *iron ore*, in large slabs and flat balls 10 or 12 inches thick, 12′ to 15′, ...	15′	0″
11. Dark colored slaty beds as before, with courses of iron balls as before, at intervals of 60 to 80 feet, ...	70′	0″
12. Shale or slate, with more balls of iron ore, ...	20′	0″
13. Slate again, with seams and flattened masses and balls of iron ore, ...	15′	0″
14. Slate continued, to a spring of strong chalybeate or ferruginous water, ...	20′	0″
15. *Fourth coal bed*, of an extremely hard quality, called splint coal, 10 inches, ...		
16. Black shale bed intermediate, 14 inches, ...	4′	0″
17. *Fifth coal bed*, very hard, like the first bed, and partially resembling the cannel coal and that in bed No. 29 of Coal Run, 2 feet, ...		
18. Dark shale and rotten or shivery argillaceous slate, . .	6′	0″
19. *Sixth coal vein*, a small bed, showing only 4 inches thick on the face of the hill.		
20. Below the vein, slate of a similar quality continues many feet.		
Total, ...	173′	00″

NOTE.—It will be perceived that the great characteristic distinction of this section is the prevalence and vast thickness of slate. Instead of the intermixed series of siliceous sandstones and argillaceous shales, as in the foregoing examples, we have here a vast mass of slate, at least 250 feet thick, comprising within it the subordinate series of coal and iron seams.

No opening having been made in any of these beds of coal, except a few inches, a fair estimate either of quality

or thickness cannot yet be obtained, and they can only be regarded as specimens of surface coal.

From the extreme hardness of the lower beds of coal it is probable that they are not greatly affected by atmospheric agency even at the outcrop.

7. *Tioga Valley Section.*

Height of strata at 7½ miles by estimation above Blossburg:

1. Hard yellow sandstone.	
Traces of coal and iron ore washed in the creek,	18′ 0″
Yellow laminated sandstone	16′ 0″
Hard ferruginous sandstone,	
2. Red shale, with shells at fork,	2′ 0″
3. Conglomerated sandstone and green shale,	4′ 0″
4. Red argillaceous shale,	2′ 0″
Sliding bank with coal and iron ore fragments washed down.	
5. Yellow sandstone, laminated beds,	23′ 0″
6. Green and red argillaceous shale,	30′ 0″
7. Unexamined ground, on account of the alluvium and gravel,	
Shale fragments,	
8. Sliding bank, with much coal and coal shale,	10′ 0″
Yellow shale and claystone fragments,	
Hard brown sandstone, horizontal,	
Loose cannel coal, in fragments, washed,	
9. Sandstones,	
Fishing Camp,	
Mouth of Fellow's Creek,	24′ 6″
Laminated sandstone,	
10. Alternating beds of red argillaceous slate, and laminated sandstone,	7 6″
11. Blue slate,	3′ 0″
Fragments of hard or splint coal.	
12. Fine laminated gray flagstone,	12′ 7″
13. Fine whetstone bed,	10′ 0″
14. Argillaceous flagstones,	13′ 0″
Pyramid rock in river,	
15. Obscure strata, chiefly sandstone,	16′ 0″
Loose balls of ore,	
Fragments of cannel coal,	
Masses of fine argillaceous iron ore,	
16. Sandstone beds, dipping North,	13′ 0″
Big gritstone rock in river, 94 tons,	
17. Ferruginous sandstone,	10′ 0″
18. Horizontal strata,	

19. Siliceous ore in large masses and balls, loose, ... Big Pine tree, ...	15′ 0″
20. Sandstone, obscure, ... Fork of Morris Run, ...	17′ 0″
21. Sandstones, dipping West, ...	13′ 5″
22. Clay deposit, with ferruginous nodules . . . . Level of Blossburg bridge, ...	34′ 0″
Total, ...	304′ 0″

NOTE.—The Tioga above the narrows passes through wide bottoms and alluvial flats, and does not wash the banks so as to show the mineral or other strata. These beds are therefore imperfectly ascertained, and would require further time to be investigated satisfactorily.

The levels were ascertained by instruments to the height of 216.83 feet, beyond that point the elevations were merely by estimation.

8. *Fellow's Creek Section.*

1. Rise of ground to summit flat, estimated at 260 feet above last observation. Chiefly sandstone series of the coal measures, . . .	200′ 0″
2. Sandstone beds at 7½ miles N. E. from Blossburg. Deer Lick above Fellow's falls. Top of upper falls and of puddingstone strata. Bottom of upper falls, in ledges.	
3. Thickness of conglomerate gritstone or puddingstone.	60′ 0′
Top of second fall. Bottom, perpendicular. Top of lower or 3d fall, puddingstone ledges, dipping west, ...	17′ 0″
4. Sandstone ledges, ... Deep basin or trout hole, 8 feet deep, ...	8′ 0″
5. Argillaceous shale, ... Bottom of lower falls.	8′ 0″
6. Yellow sandstone ledges, ... Coal slate washed in creek, ... Course of creek, N. E., ...	12′ 0″
7. Sandstone beds and strong mineral spring. Little run from the west, with coal slate, probably washed at least 150 feet down, ... Traces of soft bituminous coal in east bank, ...	20′ 0″
8. Argillaceous beds, ... Mineral spring, and bed of iron ore in seams, ... Argillaceous strata, ...	30′ 0″
9. Iron ore masses, loose in creek, ... Small run from the west containing coal fragments at 80 to 100 feet up, ...	20′ 0″

10. Ground obscured by alluvium, gravel and vegetation, Coal fragments in creek, Cannel coal fragments in the creek, Coal traces,	29′ 0″
11. Strata doubtful, but apparently chiefly argillaceous, Mineral spring, Iron ore balls. washed, Ledge of argillaceous rock, 5 feet, Little Fall,	29′ 0″
12. Argillaceous strata, Loose iron ore masses, Fishing camp at Forks, Fork of Tioga and Fellow's Creek,	42′ 0″
13. Sandstone, laminated beds,	38′ 0″
14. Argillaceous rocks, flagstones, whetstones and shales, Coal and iron ore at various elevations washed, 15. Sandstone series, To level of Blossburg bridge,	137′ 0″
Total,	650′ 0″

NOTE.—The central part of this section is almost entirely obscured by alluvial matter, and few opportunities exist of exploring the hillsides, consequently, the single exploration that has been made is by no means complete.

The levels were taken by instrument $5\frac{1}{4}$ miles from Blossburg; beyond this, the upper part was finished in part by estimation and partly by admeasurement.

The three falls in this creek have a descent of about one hundred feet in an eighth part of a mile, where the beds of hard conglomerate gritstone have checked the erosion of the channel, as in the case of most of the other ravines. At this point the creek is limited to a narrow gorge or chasm, in one place only twelve feet wide, having its edges rise almost perpendicular to the height of from 80 to 100 feet. Near the foot of the second fall is another which is precipitated from the east cliff about 65 feet, over the entire mass of conglomerate. On ascending the bed of this eastern stream, above the fall, traces of coal were abundantly discovered.

Argillaceous Iron Ore

Occurs in numerous beds under different forms and of variable qualities, interstratified with the coal, clay and slate beds. In form, they comprehend the three varieties known

to most English and to all Welsh miners by the distinctive terms of *veins*, or continuous parallel seams; *pins*, or small nodular kidney shaped concretions; and *balls*, or larger, detached, oval, flattened masses, from 1 to 4 feet long, sometimes irregularly interspersed, but more often occurring in horizontal *courses*. Those of the first mentioned form are the least, and of the third description, the most prevalent in the district under investigation.

In point of quality, the pins or kidney shaped ores are somewhat the weakest, the veins are the most siliceous and most difficult to be fluxed, and the balls are commonly the richest, and the easiest or most profitable to convert into iron; and without entering into analysis, both the balls and kidney ores may be stated as fully equalling the similar argillaceous ores from whence the foreign iron imported into this country is derived.

With regard to quantity or amount—a material question undoubtedly—this mineral, although abundant in the aggregate, is not in all cases so conveniently circumstanced for mining, as the most economical system of working might require. Yet in all the ravines there are positions where the courses are sufficiently contiguous to be excavated to advantage.

With the exception of a few small openings, on trial for this mineral, so little has been heretofore attempted to exhibit the positive amount procurable from any mine, or in any particular bed, that calculations can only be made with safety or precision, after the investigation shall have been pursued on a larger and more practical scale than the writer was at liberty to do. In Bear Creek two sections are exposed in which are several courses of good ore in balls, which would yield a considerable supply for a furnace. Coal Run intersects iron ore beds in eight or nine different positions. Besides various courses of ball mine, here are two seams, of a siliceous or gritty ore, and the kidney variety, or pins, of which about 350 tons have been raised with the intention of smelting, as soon as the furnace is completed. The specific gravity of the kidney ore, averages 3.411, its weight per cubic foot, 211 pounds, and the

gross produce or weight per acre, 1 foot thick, is 4.122 tons. Any of these beds can be worked with ease by means of horizontal drifts or levels. In the lower part of this ravine is a thick deposit, peculiar to this locality, of a red semi-indurated clay, containing an admixture of oxide of iron. Its specific gravity is 2.514, but it is too poor to be worked for the ore.

A deposit of clay occurs in the hill side, three quarters of a mile up the Tioga, and probably is an extension of this bed. It contains masses of argillaceous iron ore. This is at only 30 feet above our common base. The siliceous or sandy ore of Coal Run, contains a considerable admixture of iron: its weight being about 200 pounds to each cubic foot. One vein is from 15 to 18 inches thick, and another is somewhat less.

Large masses of siliceous ore are found in the Tioga at elevations of not more than 60 to 80 feet, and it is probable that a considerable bed of it exists about two miles above Blossburg in the rocks bordering the river.

Slabs of argillaceous ore were discovered in Taylor's Creek, at different elevations, about 4 miles south of Blossburg; also in Fellow's Creek, 5 or 6 miles to the north-east.

Our section of Boon's Creek, bed No. 8, shows some courses of excellent balls of ore, which might conveniently be worked with the superincumbent coal vein No. 7.

Johnson's Creek may be remarked for the numerous courses of this mineral, occurring at irregular intervals, throughout a thickness of more than 200 feet of slate and shale. Beds No. 2 and 9 in that section, contain several courses of flat balls and tabular masses, ten or twelve inches thick, of strong rich ore; some of them containing three cubic feet, and weighing six hundred weight. Specific gravity 3.999, weight per cubic foot, 250 pounds, and yielding 4,850 tons per acre for every foot in thickness.

One of the richest beds of ball mine occurs in Morris' Run, section No. 4, consisting of five or six courses, some of the balls being three or four feet long, and upwards.

Specific gravity of this ore, ...	3.440
Weight per cubic foot, -	215 lbs
Weight per acre, for each foot, ...	4.200 tons

The clear produce of this bed may be estimated at more than five thousand tons per acre. There is no reason to conceive, on comparing the sections of various ravines, that all these deposits are co-extensive with the entire coal region.

The highest position at which I have discovered good ball ore is at the height of 420 feet above the Tioga, toward the summit of Bear Creek, and the lowest is about 180 feet above the same river at Coal Run; so that here also is a range of about 240 feet, containing beds of iron ore.

Pipe ore in small quantities has been met with near Johnson's Creek.

Bog ore occurs sparingly except at a few points, which have not been very satisfactorily explored. At the summit of Johnson's Creek is a bed of this description of ore three feet thick."

It is not necessary to reproduce in detail Mr. Taylor's description of the character and quality of the Blossburg coal, inasmuch as all his information on the subject, which was necessarily limited, is embraced in the mass of information on that subject which is given in the detailed chapter describing the various mining operations in the basin, and more especially and fully in the chapter on the character and condition of the Blossburg Coal.

Mr. Taylor's information concerning the coals and iron ores is summed up in the following table:

The following table represents the comparative specific gravity, cubical contents, weight and gross produce per acre of the principal varieties of coal, iron and stone referred to in the foregoing article:

COAL.	Specific gravity.	Weight of one cubic yard.			Thickness of the vein.	Gross contents or weight per acre of each vein.
		Tons	Cwt	Lbs	Feet	Tons
Knap's Coal in Coal Run, . . .	1.367	1	0	60	3.75	6,252
Knap's Coal in Coal Run, 2d experiment—select and pure,	1.371	1	0	73		
Knap's Coal in Coal Run, 3d experiment—rather slaty, .	1.400	1	1	10		
Clement's Coal in Bear Creek, average, ...	1.398	1	1	7	3.25	5,530
Bloss Coal in Bear Creek, lighter part of vein, ...	1.378	1	0	85	3.00 to 3.25	5,123
Bloss Coal, in Bear Creek, heavier part of same vein, .	1.432	1	1	64		
Bloss Coal in Bear Creek, average of the coal, ...	1.405	1	1	19		
Johnson's Creek, Splint Coal, two veins, ...	1.493	1	2	55	3.00	5,442
Cannel Coal in Coal Run, at the cross, ...	1.716	1	5	96		
Cannel Coal of the purest quality, ...	1.750	1	6	41		
Big Vein in Morris Run, by estimation, ...	. . .	. . .	. . .	. . .	6.50	10,652
Little Vein of very pure inflammable coal in Coal Run, under the Kidney Ore, . . .	1.500	1	2	65	1.25	2,115
Limestone from Limestone Hill, ...	2.667	2	0	20		
Coarse grained, Millstone Grit,	2.505	1	17	83		
Fine Siliceous rock, or petrosilex, locally called marble, .	2.703	2	0	81		
Red ferruginous clay of Coal Run, ...	2.514					

Argillaceous Iron Ore.	Specific gravity.	Weight of one cubic foot.		Weight of one foot thick per acre.
		Cwt	Lbs	
Weak ball ore, on surface, below Clement's coal,	3.047	1	78	3,694
Kidney shaped ore, or pins, raised for furnace,	3.400	1	98	4,083
Second experiment,	3.423	1	102	4,161
Average,	3.412	1	100	4,122
Ball ore in the bed of Bear Creek, 42 feet above the Tioga River,	3.212	1	89	3,908
Ball ore in large masses at Morris' Run,	3.440	1	103	4,200
Ball ore in rich nodules at Johnson's Creek,	3.999	2	26	4,852
Vein of siliceous or sandy ore in Coal Run, fine grained,	3.135	1	86	3,850
Second experiment, coarse grained,	3.196			

Report of the First Pennsylvania Survey.

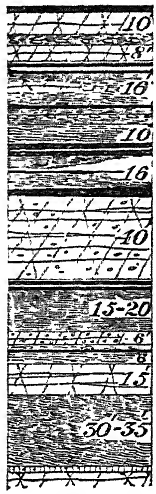
At the time when the report on the Blossburg Coal Basin was made for the First Geological Survey of Pennsylvania, the region just around Blossburg was being actively worked, and a perfect section was obtained and published; and also some complete sections on Morris Run, Coal Run, and Bear Creek.

These sections, in conjunction with those given on the preceding and succeeding pages, make a very accurate record of the measures of the basin, the sections reproduced from the Final Report being made at different points in the basin, and in some cases, as at Blossburg, in places where a section is not now obtainable in such complete detail, owing to abandonment of workings; while the sections now for the first time produced are constructed from actual shaftings and borings at workings which did not then exist.

The First Survey thus reported the vertical section of the measures on Morris Run, as furnished by Mr. Young:*

* Final Report of Penn'a, Vol. II, p. 519.

17.



Coal, all good,	4′ 0″
Sandstone, somewhat pebbly,	8′ to 10′ 0″
Shales, with balls of iron ore,	4′ to 5′ 0″
White and gray sandstone,	6′ to 8′ 0″
Bituminous slate,	1′ 3″
Coal,	1′ 5″
Bituminous slate,	2′ 6″
Coal,	0′ 2″
Slate and sandstone,	16′ 0″
Coal, resting on fireclay,	1′ 4″
Slate,	3′ 0″
Slate, with balls of ore,	4′ 0″
Strong slate,	10′ 0″
Coal, in two benches,	5′ 6″ to 6′ 0″
Slate and fireclay, with 8 inches of *coal* in the middle,	10′ 0″
Coal,	3′ to 5′ 0″
Pebbly sandstone,	40′ 0″
Shale,	[illegible] 0″
Coal,	1′ 4″ to 1′ 6″
Slate,	1′ 0″
Coal,	1′ 3″
Slate,	15′ to 20′ 0″
Conglomerate,	6′ 0″
Iron shale, with very little ore,	3′ 0″
Coal,	0′ 10″
Clay slate,	6′ 0″
Green sandstone,	15′ 0″
Red shale, or marl,	30′ to 35′ 0″
Sandstone, with 3 feet of sandy limestone,	
Total,	224′ 3″

The vertical section of the measures at Blossburg is given in the Final Report, as furnished by the Messrs. Evans, as follows:*

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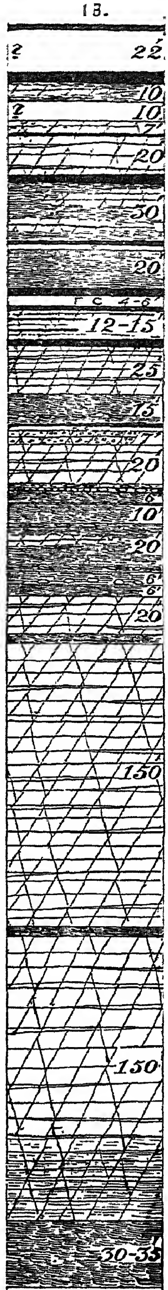
* Final Report of Penn'a. Vol. II, p. 520.

13.



Coal, all good,	3 6″
Space,	22′ 0″
Coal, 3′ 6″ good,	4′ 6″ to 5′ 0″
Slate and sandstone,	10′ 0″
Blank, about	10′ 0″
Pebbly sandstone,	7′ 0″
Coal,	0′ 10″
Sandstone,	20′ 0″
Coal, dirty,	2′ to 5′ 0″
Slate and sandstone,	30′ 0″
Coal,	1′ 3″ to 1′ 6″
Fireclay,	3′ 0″
Slate,	20′ 0″
Coal, 3′ good, the Morris bed,	3′ 6″
Fireclay,	4′ to 6′ 0″
Coal,	2′ 0″
Argillaceous sandstone and slate, with two thin coals.	12′ to 15′ 0″
Coal, thickest at Bear Creek,	3′ to 4′ 0″
Micaceous sandstone, thin bedded,	25′ 0″
Shale, with 1′ kidney ore,	15′ 0″
Coal, Kidney bed,	4″ to 1′ 6″
Impure fireclay,	2′ 0″
Pea Conglomerate,	7′ 0″
White sandstone, in part suitable for making glass,	20′ 0″
Total,	238′ 10″

The measures below the coal are given as follows, joining on to the bottom of the above section

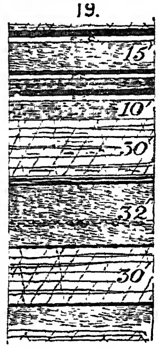
Shales, with lean Oolitic ore,	1′ 6″
Ore,	1′ 6″ to 2′ 0″
Red and mottled shale,	6′ 0″
Ore,	0′ 6″
Shale,	10′ 0″
Shale, with coarse nodular ore,	2′ 0″
Argillaceous sandstone and slate,	20′ 0″
Shale, with 1′ 6″ of gray ore,	4 0″
Slate, with 7″ of ore,	6′ 0″
Slate,	6′ 0″
Dark-brown micaceous sandstone,	20′ 0″
Red shale and green slate,	5′ 0″
Greenish-gray sandstone to level of railroad	150′ 0″
Red shale, about	4′ to 5′ 0″
Vespertine sandstone, calcareous bed about 30 feet from bottom,	150′ 0″
Red shale and marl,	30′ to 35′ 0″
Green flaggy sandstone,	—
Total,	423′ 0″

The following section exhibits the alternation of Vespertine and Ponent strata, displayed at Blossburg:*

Brown concretionary calcareous Conglomerate,	0′ 0″
Greenish grey flaggy sandstone.	20′ 0″
Brecciated or lower calcareous Conglomerate,	1′ to 4′ 0″
Greenish and bluish grey micaceous sandstone,	20 0″
Red marl, streaked with blue blotches,	10′ 0″
Red marly shale,	30′ 0″
Grey micaceous sandy slate,	2′ 0″
Greenish grey micaceous sandstone,	0′ 0″
Total,	86′ 0″

The vertical section of the measures showing on Coal Run is thus given:†

19.

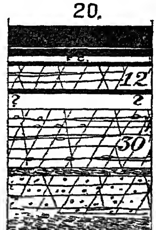


Brown sandstone, with kidney ore shut out by the sandstone shelly, thin,	
Coal, chiefly cannel,	3′ 0″
Fireclay,	2′ 6″
Shale,	15′ 0″
Coal, (the fireclay coal,)	1′ 6″
Fireclay,	2′ 6″
Shale,	2′ 0″
Nodular ore band,	0′ 4″
Shale,	3′ 0″
Coal, (the Morris bed,)	3′ 6″
Fireclay,	2′ 6″
Slate,	10′ 0″
Sandstone, vegetable remains,	30′ 0″
Fireclay,	0′ 6″
Coal, cannel, (including two seams of slate, 12 and 3 inches thick,)	3′ 10″
Shale, with rich kidney ore, (aggregate thickness 6 inches in 3 feet of shale,	32′ 0″
Coal, too far below the ore to be worked with it: this is the kidney coal,	1′ 0″
Sandstone,	30′ 0″
Coal, cannel,	2′ 0″
Olive shales, thickness unknown,	—
Sandstone, with vegetable remains passing downwards into Conglomerate,	—
Total,	145′ 2″

Then the Vespertine red shales are seen alternating with sandstone strata.

The vertical section of the measures in Bear Creek is given as follows:†

20.



Coal, variable, sometimes 1 foot shale, embracing 4 inches of iron ore,	10 to 12′ 0″
Coal,	3′ 7″
Fireclay,	2′ to 3′ 0″
Coal, lower half cannel,	1′ 2″
Dark sandstone,	12′ 0″
Coal,	1′ 6″
Interval,	—
Sandstone, imbedding pebbles,	30′ 6″
Shale, containing iron ore,	3′ to 4′ 0″
Sandstone, conglomerate,	—
Umbral shales,	—
Total,	67′ 3″

The upper coal occurs on the south side of the creek,

* Final Report of Penn'a, Vol. II, p. 522.
† Final Report of Penn'a, Vol. II, p. 521.

where it is 1 foot 6 inches thick, but on the north side it is entirely wanting.

The ore in the next stratum is good, but small in quantity; the bed is also visible in Coal Run.

The next bed is the main coal seam of Blossburg; it has been opened in five different drifts, two on the south side and three on the north side of the creek, at an elevation of about 280 feet above the railroad, not quite a mile distant. The quality of this coal is somewhat injured by the amount of sulphuret of iron occasionally present, from which, however, the chief part of the bed is comparatively free, having a fine brilliant lustre. A fault, crossing the three drifts on the north side of the creek in a N. E. and S. W. course, throws down the coal 3 feet. The fireclay under this coal contains *Stigmaria ficoides*. At its outcrop occurs large deposit of exceedingly tough clay derived from this bed, well adapted for the manufacture of fire bricks.

The 18 inch seam of coal has been partially mined. The sandstone which underlies it is rather remarkable, passing in its lower bed into a coarse conglomerate.

Under the latter lies another sandstone, and beneath that the Umbral Red Shale.

Beneath the Seral Conglomerate a band of iron ore was struck, which upon being pursued into the hill, thinned entirely away. Its appearance justifies further exploration.

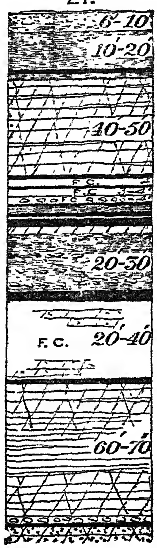
The shale containing this ore is nearly 5 feet thick; at its outcrop the ore consists largely of long elliptical balls of a very argillaceous brown ore, lying closely adjacent to each other, and forming more than one-half of the stratum. Each elongated nodule exhibits externally a series of concentric crusts, which readily peel off by exposure to the atmosphere. Beneath the balls lies a nearly solid layer of a heavy yellowish-gray ore, about 6 inches thick, having a true oolitic structure. These beds appear to be shut out by the overhanging sandstone at a short distance from the surface. Other excavations have been made for ore in the other red bands lower down in the series, but unsuccessfully. The conglomerate and sandstone of the two beds described, strew the hill-sides in great quantity, and furnish an excellent building material."

Fall Brook Mines.

The most eastern and northern part of the Blossburg Coal Basin, where extensive development of the coal has been made, is at Fall Brook. Here the Fall Brook Coal Company have been mining on a large scale for years, and have a very costly and complete plant, including mines, coal dumps, railroad, and a well built village. The mines are 1842 feet above tide. The railroad from Blossburg to Fall Brook is eight miles in length.

The complete vertical section of the measures at Fall Brook is thus given by Mr. Hardt, chief engineer of the company, compiled from old shaft openings, borings, &c.:

21.



Surface,		—
Loose drift,		6′ to 10′ 0″
Black slate,		10′ to 20′ 0″
Coal, (Seymour or Cushing Vein,)		2′ 8″
Black and gray slate,		3′ 0″
Sandstone,		10′ to 30′ 0″
Coal, (Morgan or Dirty Vein,)		2′ 0″
Fireclay and Bastard,		4′ 0′
Coal,		0′ 8″
Fireclay,		3′ to 4′ 0″
Fireclay, (with iron ore balls,)		3′ to 4′ 0″
Coal,		0′ 6″ to 1′ 0″
Black slate,		3′ to 4′ 0″
Coal,		1′ to 2′ 0″
Gray slate,		0′ 6″ to 1′ 0″
Coal,	1 0″	} 3′ 8″
Bony *coal*,	0′ 8″	
Coal,	1′ to 2′ 0″	
Sandrock,		2′ to 4′ 0″
Gray and black slate, (with iron ore balls,)		20′ to 30′ 0″
Coal, (Bloss Vein,)		3′ to 5′ 0″
Bastard fireclay and rock mixed,		20′ to 40′ 0″
Coal, (Bear Creek,)		2′ to 3′ 0″
Bastard rock and sandstone,		60′ to 70′ 0″
Kidney ore balls and slate,		1′ to 3′ 0″
Coal, (Kidney Vein,)		1′ to 2′ 0′
Conglomerate sandstone rock,		—
Total,		269′ 0″

The section at Fall Brook, as compiled by myself, with the assistance of Mr. Pollock, chief miner, varies slightly from the above. It is as follows:

Surface,	—
Dark-blue sandy slate,	9′ 0″
Bluish slate, (iron ore in thin flakes,)	10′ 0′
Coal, Seymour Vein, not worked,	2′ 6″
Rough, sandy, impure fireclay,	2′ 0′
Sandstone, thin bedded usually, much current bedded, with numerous thin conglomerate layers, small, white, round pebbles, called "Monkey Ledge,"	40′ to 60′ 0″

Slaty *coal*, and fireclay, "Monkey vein," worthless at this place,	3′ 0″
Dark-blue slate, (ore balls,)	8′ 0″
Coal, small,	0′ 6″
Dark-blue slate,	6′ 0″
Coal, small,	0′ 6″
Dark-blue slate,	6′ 0″
Coal, "Dirty Vein," { Coal, 2′ 0″ / Slate, 1 3″ }	3′ 3″
Rough, hard fireclay,	2′ 0″
Gray, shaly rock,	20′ 0″
(Place of "Fireclay coal bed," wanting at Fall Brook.)	
Fireclay, kidney ore on bottom,	2′ 0″
Compact, light-gray S. S.,	9′ 0″
Clay slate, 0′ to	5′ 0″
Coal, (Bloss Vein,)	4′ 0″
Fireclay, sometimes pure and valuable,	3 0″
Sandy slate, some sandstone layers,	16 0″
Coal and slate, (Bear Creek,)	1′ 6″
Sandy clay, (some ore in bottom,)	4′ 0″
Reddish-brown sandstone, 25′ to	30′ 0″
Compact white sandstone,	18′ 0″
Conglomerate sandstone,	14′ 6″
Reddish, sandy shale,	9′ 0″
Slate, holding ore balls,	2′ 6″
Black slate and coal, (Kidney vein,)	1′ 0″
Sandstone,	—
Total,	251′ 1″

The Seymour (*or Cushing*) coal bed is only opened at Fall Brook on the outcrop for examination; no regular drift has been run in upon it, and no coal shipped from it to market.

A specimen of coal taken from the outcrop was forwarded for analysis, and yielded (A. S. McCreath):

The coal is very tender, bright, shining, with somewhat columnar structure and cubical fracture. It contains numerous thin partings of mineral charcoal and iron pyrites.

Water,	1.970
Volatile matter,	20.105
Fixed carbon,	68.360
Sulphur,	1.795
Ash,	7.770
	100.000
Coke, per cent.,	77.925
Color of ash,	Lilac.
Sulphur left in coke,	1.222
Per cent. sulphur in coke,	1.568
Per cent. of sulphur volatilized in coking,	31.92
Per cent. iron in coal,	.882

Sulphur taken up by iron,	1.007
Free sulphur,	.788

This analysis shows the Seymour bed at Fall Brook as of only medium quality, and with too high a percentage of sulphur; though in the last respect allowance must be made for an imperfect specimen, taken from outcrop, and not under sufficient cover. But the Bloss bed at Fall Brook has proved so large in size, so excellent in quality, and so economical in working, that the other beds of the measures have hitherto been neglected.

The sandstone which underlies the Seymour coal bed is one of the most marked and persistent features of the Blossburg Coal Basin. It is known in all the different localities as the "*Monkey Ledge;*" is from 40 to 60 feet thick, averaging 50 feet; is thin bedded usually, though with occasional massive plates, and is enormously current bedded, with numerous layers of conglomerate sandstone through the mass, scattered at no regular intervals, usually in thin plates, with white, rounded quartz pebbles. Always recognizable, and usually noticeable by making cliffs near the hill tops, it is the great mark and guide to the geology of the Basin.

The "*Monkey Coal*" bed has been drifted in upon by the Company, but never mined.

The coal is of fair quality, though somewhat more ashy than the others, but is so mixed with slate and dirt as to be worthless at this place.

A specimen of the coal yielded, on analysis: (A. S. McCreath.)

The coal has a dull, dirty appearance, being for the most part coated with infiltrated silt. On fresh fracture it shows bands of bright crystalline coal, and considerable slaty coal. It carries numerous thin partings of mineral charcoal and some iron pyrites.

Water,	1.560
Volatile matter,	20.740
Fixed carbon,	66.587
Sulphur,	.773
Ash,	10.340
	100.000
Coke, per cent.,	77.700
Color of ash,	Reddish gray.

This coal lies directly at the bottom of the "Monkey Ledge."

The "*Morgan or Dirty Vein*" of coal, lying under the "Monkey Vein," has been drifted into by the Fall Brook Coal Company, but never mined for shipment.

The coal of the bed is good, but is too much intermingled with dirt, clay, and slate to be economically worked out in in a clean condition for market.

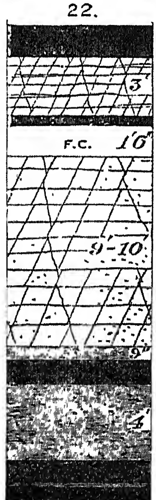
A specimen of the coal yielded on analysis (A. S. McCreath):

The coal has a dull, dead lustre, being generally coated with silt. On fresh fracture, the coal is bright, crystalline, and columnar. It carries numerous thin partings of mineral charcoal, and some iron pyrites.

Water,	2.820
Volatile matter,	17.975
Fixed carbon,	71.326
Sulphur,	.634
Ash,	7.245
	100.000
Coke, per cent.,	79.205
Color of ash,	Reddish gray.

The measures between the "Monkey Vein" and "Morgan," or "Dirty Vein," were exposed in detail at one place, and showed as follows:

22.



Sandstone,	—
Coal, "Monkey Vein,"	1′ 8″
Sandstone, thin-bedded,	3′ 0″
Coal,	0′ 7″
Fireclay, variable, av'ge,	1′ 6″
Sandrock,	9′ to 10′ 0″
Slate, bluish,	0′ 9″
Coal, (not worked,)	1′ 3″
Slate, bluish,	4′ 0″
Coal, "Dirty Vein,"	1′ 2″
Slate, "Dirty Vein,"	0′ 3″
Coal, "Dirty Vein,"	0′ 10″
Total,	25′ 0″

But the coals themselves, and the measures immediately enclosing them, are subject to rapid and serious changes, both in character and thickness.

The "*Fireclay Vein*" of coal is not found at Fall Brook; shale, holding balls of iron ore, occupying the place held by the Fireclay Vein at Arnot.

The next coal bed in descending order is the *Bloss* coal bed.

This is the most important bed of the Basin, and the one which has hitherto yielded almost all of the "Blossburg coal" shipped from the region.

At Fall Brook all the coal shipped to market, nearly two millions of tons, has come from the mines on this bed. The mines of the company are in most admirable order, and the plant is expensive and complete, embracing everything that a judicious development would call for.

The coal runs in thickness from three feet four inches to five feet; averaging four feet six inches. It has no regular parting slate in the No. 3 mine; but has parting slates where worked off to the north. This slate was 8 inches thick, in three layers, and with usually 6 inches of bottom coal under the lowest slate.

A specimen of the Fall Brook Bloss bed coal yielded on analysis (A. S. McCreath):

The specimen contains bright crystalline tender coal, with columnar structure and cubical fracture. Also, bright resinous, slaty, cannel-like coal, having a somewhat conchoidal fracture.

Water,	1.050
Volatile matter,	18.540
Fixed carbon,	69.934
Sulphur,	.661
Ash,	9.815
	100.000

Coke, per cent.,	80.41
Color of ash,	gray.
Sulphur left in coke,	.561
Per cent. sulphur in coke,	.696
Per cent. iron in coal,	.133
Sulphur taken up by iron,	.152
Free sulphur,	.409
Per cent. sulphur volatilized by coking,	15.12

This analysis represents a fair average specimen of run of mine coal as shipped in quantities to market.

A specimen of the crystalline coal, which runs in streaks through the Fall Brook Bloss coal bed, was analyzed separately, and yielded (A. S. McCreath):

Water,	1.000
Volatile matter,	20.830
Fixed carbon,	70.854
Sulphur,	.796
Ash,	6.520
	100.000
Coke, per cent.,	78.170
Color of ash,	gray.

The cannel-like coal yielded on separate analysis (A. S. McCreath):

Water,	1.200
Volatile matter,	17.110
Fixed carbon,	66.212
Sulphur,	.568
Ash,	14.910
	100.000
Coke, per cent.,	81.69
Color of ash,	gray.

In the cannel-like coal, the coke is only slightly coherent.

Mr. Pollock reports that the Bloss Vein in going north from mine No. 3 takes in more slate; and that to the north and north-east, a distance of from one to two miles away, the bed had run down to a thickness of nine inches.

The general average rise of the coal is to the south-east about 3′ in the 100′; the dip therefore being to the north-west.

Fall Brook village, however, is not exactly at the centre of the basin, or on the centre of the synclinal axis.

The *Bear Creek* coal bed has been opened up at Fall Brook by the company.

A well-timbered drift was put in on the coal, and continued far under perfect cover, but the bed never rose to a steady workable thickness. It is called one and a half feet to two feet thick, but will average more nearly one and a half feet than two feet in thickness.

The coal itself is good and firm, but contains more ash than the Bloss bed above it.

A specimen of the average run of the bed was analyzed at Harrisburg, and yielded (McCreath):

The specimen consists of bright crystalline columnar coal with numerous thin partings of mineral charcoal, and some iron pyrites; and compact resinous cannel-like coal having a conchoidal fracture.

Water,	.790
Volatile matter,	20.965
Fixed carbon,	65.465
Sulphur,	.725
Ash,	12.055
	100.000
Coke per cent.,	78.225
Color of ash,	gray.
Sulphur left in coke,	.526
Per cent. sulphur in coke,	.672
Per cent. iron in coal,	.245
Sulphur taken up by iron,	.280
Free sulphur,	.445
Per cent. sulphur volatilized by coking,	27.44

A specimen of the crystalline coal from the Bear Creek coal yielded on analysis (McCreath):

Water,	.770
Volatile matter,	22.180
Fixed carbon,	67.191
Sulphur,	.799
Ash,	9.060
	100.000
Coke per cent.,	77.050
Color of ash,	gray.

A specimen of the cannel-like coal from the Bear Creek coal yielded on analysis (McCreath):

Water,	.800
Volatile matter,	15.720
Fixed Carbon,	59.299
Sulphur,	.471
Ash,	23.710
	100.000
Coke, per cent.,	73.480
Color of ash,	Gray.

In the cannel-like coal the coke is only slightly coherent.

The *Kidney* coal bed at Fall Brook shows only 6 inches to 12 inches of coal and black slate; it is entirely worthless.

A micaceous slate overlying the coal holds numerous kidney iron ore balls; but while the balls are very numerous in places, yet there does not seem to be any regular and persistent plate of iron ore.

The ore balls are, as is usual with the Kidney balls, of excellent quality.

The massive sandstone which is between the Bear Creek and Kidney coal beds, about 60 feet thick, is made up of an upper layer, 35′ to 45′ thick, of massive gray sandstone, with numerous layers of pebble rock, of rounded, white quartz pebbles, usually not large; the rock stands out on massive cliffs and makes the falls at Fall Brook; and of a lower layer of about 20′ thick, usually thin bedded, much iron stained, sometimes with beds so ferruginous as to be almost a reddish brown sandstone, and without pebbles.

This sandstone rests directly upon the micaceous slate holding kidney iron ore balls, which overlies the Kidney coal bed

Morris Run Mines.

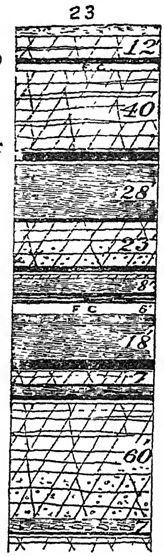
Only two miles west of Fall Brook are the extensive mines of the Morris Run Coal Company. These mines are opened and worked by the company, on Morris run, three miles east from Blossburg.

They have their own railroad to Blossburg, and a most extensive and complete plant at their mines.

The mines are 1,678 feet above tide water, and are geo logically just about at the centre of the basin, or on the middle of the synclinal axis.

The detailed section of the measures showing at Morris run is thus given by Mr. W. S. Neering, Superintendent. The numerous test pits, air shafts, &c., have enabled these measures to be given in complete detail.

The section is:



Surface,	—
Drift,	5' 0"
Firegrit sandstone,	12' 0"
Coal, ("Rock Vein,")	2' 6"
Fireclay,	4' 0"
Yellow sandstone,	40' 0"
Slate,	2' 0"
Coal, ("Seymour, or Cushing Vein,")	4' 6"
Fireclay,	2' 0"
Slate,	28' 0"
Coal,	1' 6"
Sandstone and conglomerate,	23' 0"
Coal, ("Dirty Vein,")	2' 6"
Fireclay,	2' 0"
Sandstone,	2' 0"
Slate,	8' 0"
Cannel coal and slate,	5' 0"
Fireclay,	6' 0"
Slate,	5' 0"
Fireclay,	1' 3"
Slate,	18' 0"
Coal, ("Bloss Vein,")	5' 0"
Fireclay,	1 0"
Sandstone,	7' 0"
Coal,	1' 0"
Slate,	5' 0"
Coal, ("Bear Creek,")	2' 6"
Fireclay,	2' 0"
Sandstone and conglomerate,	60' 0"
Slate (and iron ore,)	7' 0"
Coal, ("Kidney Vein,")	1' 0"
Fireclay,	1' 0"
Sandstone,	—
	266' 6"

The upper bed of coal at Morris Run, the "*Rock Vein*," 46 feet above the "Seymour or Cushing Vein," is not worked for shipment. From openings made on the outcrop it is called a 2½ foot bed.

The *Seymour bed* has also only been opened up on the crop, and is not shipped to market.

As it underlies a considerable area in this region, and is usually of workable thickness, it was deemed advisable to ascertain its character. A specimen of the coal was taken from under good cover and forwarded to the laboratory at Harrisburg. It yielded on analysis (McCreath):

The coal has a deep black lustre, is very tender, and contains an unusually large number of thin partings of iron pyrites. These are generally nothing more than mere knife edges, but the number present in the specimen examined is very unusual.

Water,	.950
Volatile matter,	19.830
Fixed carbon,	60.759
Sulphur,	6.856
Ash,	11.605
	100.000
Coke, per cent.,	79.22

Sulphur left in coke,	4.375
Per cent. sulphur in coke,	5.522
Per cent. iron in coal,	5.558
Sulphur taken up by iron,	6.352
Free sulphur,	.504
Per cent. sulphur volatilized by coking,	36.180

The above analysis is a striking example of how easily the use of a single specimen for analysis may lead into grave error.

The analyses of the Seymour Vein coal from Fall Brook, Arnot and Antrim, all show that the Seymour coal carries much more sulphur than the Bloss coal, but is regular in its character, not exceeding say 2 per cent. of sulphur. There is no reason to believe that the average character of the bed at Morris Run is materially different, but it appeared that the lump selected for analysis contained numerous small scales of iron pyrites, not visible save by close examination under a strong glass.

It is, therefore, a totally unfair representation of the character of the Seymour coal bed in the region between Fall Brook and Arnot, and is only reproduced here to show that the analyses, though perfectly accurate for the specimens forwarded, must be closely scanned in connection with all the other features of the case before they can be accepted as conclusive of character.

Moreover, the analysis is of importance as bearing on the question of how far the *condition* of the sulphur in the coal affects the *percentage driven off* in coking. This subject will be discussed in another place.

The coal beds between the Seymour coal and the Bloss coal have not been opened up at Morris Run, except in passing through them in air shafts, &c. They are small, and of no present practical value.

The vertical sections of Fall Brook and Morris Run show that while in the main broad features there is harmony between them, yet that even in the short interval between the two places, only 2 miles, there has been sufficient room for minor details of difference to grow into marked features, which if not accompanied by the complete section, with its

general resemblance, would cause embarrassment of identification.

The *Bloss coal bed* is the one from which the widely known and esteemed Morris Run coal has been mined and shipped.

The bed is here at its very best. In size it has now full 5 feet or more of clean coal for long distances in the mines, with excellent roof and floor, lying so well for easy mining that a single mine upon it has yielded 1,500 tons of coal daily for a considerable period, when the demand for coal pushed the mining.

In character, appearance, bearing of transportation, &c., this coal is not excelled by anything in the Blossburg coal basin.

A specimen of the coal of the Bloss bed at Morris Run, representing the average run of mine of the coal as shipped to market, was forwarded to the laboratory of the survey, and yielded on analysis (McCreath):

The coal is generally bright, tender, columnar, and shows a few thin seams of cannel-like coal. It carries some mineral charcoal, and a very small amount of iron pyrites, in thin partings.

Water,	1.120
Volatile matter,	18.570
Fixed carbon,	72.097
Sulphur,	.583
Ash,	7.630
	100.000
Coke, per cent..	80.33
Color of ash,	gray.
Sulphur left in coke,	.497
Per cent. sulphur in coke,	.618
Per cent. iron in coal,	.133
Sulphur taken up by iron,	.152
Free sulphur,	.431
Per cent. sulphur volatilized by coking,	14.750

It is scarcely necessary to call attention to the analysis given above. It shows that the Morris Run coal possesses all the attributes of a steam coal, and is very free from injurious impurities.

And this character is borne out by the reputation already earned by the coal after a shipment to market of over three millions of tons.

Neither the Bear Creek coal, nor the Kidney coal are developed at Morris Run.

From outcrop openings merely the *Bear Creek* is reported as showing 2½ feet of coal, and the *Kidney* coal as giving 1 foot of coal. Neither one is now open for examination.

The lower part of the section is almost identical with the measures as shown on the Fall Brook section, and the description given of them at that place will also apply in its general features to the measures under the Bloss bed at Morris Run.

Blossburg.

No coal mining for shipment to market is now done in the immediate vicinity of the town of Blossburg. The Bloss bed covered only a limited area on the hill top near the town, and this area was steadily worked for many years. The section reproduced on page 163 from the Roger's Final Report of 1858 was made when the works at Blossburg were running, and is much more complete than could now be obtained.

In view of the reproduction of this complete section, and the fact that complete details are given in this report of the mines lying both east and west of Blossburg, the immediate vicinity of the town, therefore, will need no further elaboration of detail in this chapter.

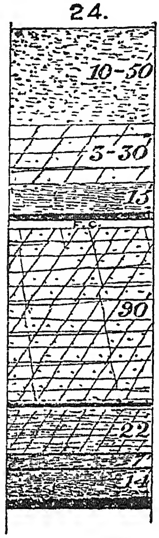
Arnot Mines.

The Blossburg Coal Company have their mines opened at Arnot, 3 miles west of Blossburg. The company have their railroad to Blossburg (and on to Elmira), a well built village at Arnot, coal shutes, coke ovens, and everything necessary for a complete and efficient plant to mine and ship economically and quickly a large daily output of coal. Arnot is 1682 feet above tide water. The measures exposed resemble in their main features the sections at Fall Brook, Morris Run and Blossburg.

The details of the vertical section as given by Mr. S. B. Elliott, the general manager of the company, are as follows:

Section at Arnot.

24.



Alluvial, varying from	10′ to 50′ 0″
Sandrock,	3′ to 30′ 0″
Dark sandy slate,	15′ 0″
Coal, (Seymour Bed,)	2′ to 3′ 6″
Fireclay,	4′ 0″
Sandrock,	90′ 0″
Slate,	2′ 0″
Coal, (Dirty,)	1′ 6″
Fireclay,	2′ 0″
Slaty sandstone,	22′ 0″
Coal, (a kind of cannel,)	0′ 6″
Slate,	7′ 0″
Coal, (Fireclay Bed,)	0′ 10″
Slate, (with some iron ore,)	14′ 0″
Coal, Bloss bed,	3′ to 5′ 0″

A diamond drill boring starting between the Bloss and Bear Creek coals continues the section on downwards, thus:

Sandstone,	11′ 0″
Coal, Bear Creek,	0′ 3″
Sandstone,	13′ 0″
Sandstone,	15′ 0″
Slate,	5′ 0″
Coal,	0′ 3″
Sandstone,	12′ 0″
Sandstone and slate,	5′ 0″
Coal, Kidney,	0′ 6″
Sandstone and slate,	10′ 0″
Small *coal*, ½ inch,	——
Sandstone and slate,	5′ 0″
Small *coal*, ½ inch,	——
Sandstone, some slate layers,	80′ 0″
Sandstone, massive,	5′ 0″
Slates,	3′ 0″
Coal,	0′ 2″
Fireclay, some sandstone layers,	10′ 0″
Conglomerate sandstone,	9′ 0″
Sandstone,	12′ 0″
Sandstone,	3′ 0″
Red rock,	15′ 0″
Total,	214′ 2″

The above measurement is taken from the core. It is incorrect, the core being imperfect, and much of the soft rock ground up.

The red rock, by measurements made at other points, is said to be fully 300 feet below the Bloss bed of coal; and in this case there is an error of 60 feet to be distributed through the above section, representing soft rocks of which no core came out.

This bottom red rock is about 6 feet thick; under it comes in a massive fine grained gray sandstone.

The *Seymour* coal bed is opened and worked for shipment by the Blossburg Coal Company at Arnot.

The bed has a slate roof with ½″ to 3″ of iron ore enclosed, and a fireclay floor; runs with considerable regularity in the mine, and will average two feet eight inches in thickness.

An average specimen of the coal was forwarded to the Survey laboratory, and yielded on analysis (McCreath):

The coal is bright, shining, and very tender. It carries numerous thin partings of iron pyrites, and an unusually large amount of mineral charcoal.

Water,	1.180
Volatile matter,	21.586
Fixed carbon,	71.574
Sulphur,	.907
Ash,	4.753
	100.000
Coke, per cent.,	77.234
Color of ash,	Reddish gray.

A coke made from this coal yielded on analysis (McCreath):

Water,	.220
Volatile matter,	.625
Fixed carbon,	90.650
Sulphur,	.850
Ash,	7.655
	100.000
Color of ash,	Gray, with red tinge.

Both the above coal and coke are of excellent character; perhaps rather higher in character than would be yielded as an average by working extensively.

The coal beds between the Seymour and Bloss coal beds are not opened up at Arnot for shipment; and where they have been touched in test pits, or in air shafts, they have proved themselves small and valueless, as is shown on the vertical section of the Arnot measures.

The "*Monkey Ridge*" shows as clearly at Arnot as at Fall Brook, and is at the former as a much current bedded sandstone, with layers of pebble rock interleaved, usually forming a cliff on the hill side, and always a marked feature and a guide for geological position.

The *Bloss coal bed* is the bed which furnishes the greater part of all the coal which has been in the past, and is now being shipped from Arnot.

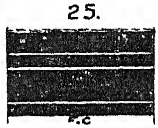
It is of its usual excellent character, and is very regular in average thickness.

There are, of course, numerous local pinches and swellings in size, as there are in all mines; but on the average it yields about three feet six inches of clear coal, or over 5,000 tons to the acre.

The coal is divided into benches; the partings being very persistent, and recognizable under their change in thickness.

On the average, the bed shows thus:

25.



Roof, slate,	
Coal, top bench, average,	1′ 0″
Slate,	0′ 1″
Coal, middle bench, average,	0′ 8″
Bone coal,	0′ 2″
Coal, bottom bench, average,	1′ 8″
Slate,	0′ 1 1-2″
Coal, "Mining coal," not worked,	0′ 8″
Fireclay floor,	---

The mining coal on the bottom of the bed is all cut up in mining, and is not counted in the estimate of the producing power of the bed.

The coal separates cleanly from the parting slates usually, except that the coal from the middle bench shows a tendency to stick to the top of the bone coal under it. This however is picked clean outside of the mine.

Specimens of the coal from the three workable benches were forwarded to the laboratory of the survey for analysis.

The upper bench yielded (McCreath):

Water,	1.190
Volatile matter,	20.755
Fixed carbon,	71.697
Sulphur,	1.023
Ash,	5.335
	100.000
Coke, per cent.,	78.055
Color of ash,	gray.

This upper bench averages 12 inches of clean coal. Though a little high in sulphur, it is very low in ash, and is the purest and strongest bench of coal in the whole bed.

The middle bed yielded on analysis (McCreath):

Water,	.940
Volatile matter,	20.640
Fixed carbon,	64.306
Sulphur,	.914
Ash,	13.200
	100.000
Coke, per cent.,	78.420
Color of ash,	gray.

This bench averages only about 8 inches in thickness. It is a good coal, though higher in ash than the upper bench.

The lowest workable bench of the coal yielded on analysis (McCreath):

Water,	1.110
Volatile matter,	18.790
Fixed carbon,	63.428
Sulphur,	.602
Ash,	16.070
	100.000
Coke per cent.,	80.100
Color of ash,	gray.

This is the main bench of coal, which yields nearly one half of all the coal coming from the Bloss bed. The percentage of ash as given by the analysis is probably higher than the average of the bed.

It is plain that a combination of the coal of these three benches, as shipped to market, will make a coal not specially high in sulphur, representing a strong steam coal somewhat high in ash.

While the Bloss bed averages from 3 to $3\frac{1}{2}$ feet of coal, say fully $3\frac{1}{4}$ feet, or 5,000 tons to the acre, some of the variations in the mine are very great.

The top bench is probably the most regular, keeping steadily at about 1 foot thick. It carries a "sulphur band," which can be picked out.

The slate partings run from 2 inches to 18 inches. All of them vary much, the bottom slate at times running down to less than $\frac{1}{4}$ of an inch.

While the chief business of the Blossburg Company at Arnot has been and is now the shipment of coal for steam and blacksmiths' use, yet well directed efforts are now being made to utilize the slack from screening by coking to ship to foundries and furnaces.

Coking.

In view of the importance to the region of the developement of this branch of trade, analyses were made of three different cokes, and one of them was tested also for burden bearing power.

The coke is made in beehive block ovens; is burned for 48 hours; is watered in the oven, as in the Connellsville region, and shows where properly burned as an open, porous, cellular, ringing, and strongly coherent coke.

It should be stated again that in mining on the Bloss bed, the middle bench coal sticks to the bone coal beneath so closely "that it is necessary to allow the miner to send the latter out, and it is taken out and cleaned at the chutes. This is done on screens over which the coal passes, and more or less of this bone is broken up in the operation, and falls in among the fine coal; and it is from the fine coal that we are now making our coke. This will explain why the coke from our No. 2 Drift, or Bloss Vein, shows so much impurity in the form of small pieces of slate and bone. This we propose to take out with a machine similar to the one used at Loyalhanna, in Westmoreland county."

The coke from the No. 2, north drift, Bloss Vein, yielded on analysis (D. McCreath):

Water,	.590
Volatile matter,	.845
Fixed carbon,	83.371
Sulphur,	.644
Ash,	14.550
	100.000
Color of ash,	Gray.

Another coke made from Bloss Vein coal, yielded (D. McCreath):

Water,	.240
Volatile matter,	.572
Fixed carbon,	83.922
Sulphur,	.679
Ash,	14.587
	100.000
Color of ash,	Gray.

These analyses showed a coke of good enough character, and apparently of sufficient strength to enable them to be applied to any of the ordinary uses for which coke is desired.

Some coke was then made from the fine coal screenings, and then tested for strength and burden bearing power.

The coal used was from the fine coal screened from market sales (Bloss bed coal).

Its general character is represented by an average of the analyses of the Bloss coal already given.

It was coked for 48 hours in the Beehive Oven; watered in oven.

The coke showed on analysis (McCreath):

The coke is generally fine, although somewhat open and porous in centre of lump. It has a bright steel-gray color, and carries considerable slate in small lenticular masses.

Water,	1.150
Volatile matter,	1.732
Fixed carbon,	80.927
Sulphur,	.764
Ash,	15.427
	100.000
Color of ash,	Reddish gray.

Both in character, general appearance and strength the coke shows very well, more especially as the enterprise when examined was comparatively new.

Specimens of the coke were forwarded to Jno. Fulton, General Mining Engineer of the Cambria Iron Company, at Johnstown, Pennsylvania, who kindly consented to test the burden-bearing power.

Mr. Fulton reports as follows:

"The coke is bright, resonant, and possesses a superior physical structure. It requires washing of the fine coal to remove considerable slate scales and increase its tenacity. With this cleansing it would make a very excellent coke for blast furnace use, carrying a burden of furnace 60 to 80 feet high."

The following table, prepared by Mr. Fulton, shows at a glance the physical properties of the coke, as compared with Connellsville coke as a standard:

Table exhibiting the physical properties of coke, submitted by F. Platt, Esq., Assistant Second Geological Survey of Pennsylvania.

LOCALITY.	GRAMMES IN 1 CUBIC INCH.		POUNDS IN 1 CUBIC FOOT.		PERCENTAGE.		Compressive strength per cubic feet in lbs.—¼ ultimate strength.	Height of furnace charge, which can be supported without crushing.	Order in cellular space.	REMARKS.
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.				
Pittsburgh and Connellsville Coke Company, taken as a standard for comparison,	12.46	20.25	47.47	77.15	61.53	38.47	284	114	I.	Very good furnace coke,
Arnot No. 1,	13.09	20.87	49.59	77.17	67.51	32.49	150	63	I.	With coal washed, a very excellent coke can be made.
Arnot No. 2,	11.16	18.67	42.50	71.12	59.71	40.29	142	57	I.	

The Blossburg Coal Company have not opened or worked the Bear Creek coal.

The vertical section given on page 178 shows that both the *Bear Creek* and *Kidney coal* are small and entirely valueless.

The boring made by the company at Arnot, 300 feet deep, carrying the section down into XI and X, has been given in detail on page 178.

It shows under the Bear Creek coal the same massive gray sandstone with but little pebble rock, much the same as has been recorded in detail concerning the measures at Fall Brook.

Antrim Mines.

The Fall Brook Coal Company, in addition to their large plant at Fall Brook, have extensive works at Antrim, eight miles west from Arnot.

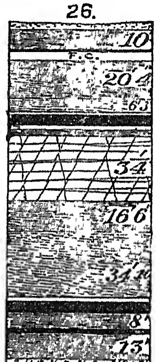
The deep cutting Babb's creek is between Antrim and Arnot, and necessitates an entirely separate outlet for the Antrim coals.

This is afforded by the Corning, Cowanesque and Antrim railroad, (which is in practically the same ownership,) by which the coal is transported via Corning, N. Y., on to Geneva, N. Y., on the New York Central railroad.

The mines at Antrim are 1,672 feet above tide.

The vertical section of the measures exposed at Antrim, are thus given in detail by Mr. Hardt, the chief engineer of the company:

26.



Surface,		—
Drift,	5′	0″
Blue slate,	10′	0″
Coal,	1′	0″
Bluish fireclay,	5′	0″
Brown slate,	20′	4″
Blue slate,	6′	3″
Black slate,	1′	4″
Coal, ("Cushing, or Seymour,")	5′	6″
Fireclay,	2′	6″
Light slate,	3′	0″
Sandstone,	34′	0″
Light rock slate,	16′	6″
Dark slate,	34′	0″
Light slate,	2′	0″
Coal, ("Bloss Vein,")	5′	4″
Black slate,	8′	0″
Coal, Bear Creek,	2′	2′
Light-colored slate,	13′	0″
Conglomerate sandstone,		—
Total,	175′	9″

The points of difference between this vertical section and those at Arnot, Morris Run, and Fall Brook, are very striking. Some coal beds are absolutely lacking; the interval rocks are different in character, and the interval distances are amazingly changed. The discussion of these changes will be found in another chapter.

The small 1 foot coal, overlying the Seymour or Cushing bed at Antrim by 33 feet, has not been opened and was not examined.

The *Seymour bed* at Antrim is given by Mr. Hardt as 5 feet 6 inches in thickness. It is not at present mined to any extent, the Antrim coal coming from the Bloss bed.

A specimen of the Seymour coal from Antrim was forwarded to the State laboratory, and yielded on analysis (McCreath):

The coal has a bright, black lustre, is very tender, and carries numerous thin partings of mineral charcoal and knife edges of iron pyrites.

Water,	1.460
Volatile matter,	21.600
Fixed Carbon,	65.120
Sulphur,	2.820
Ash,	9.000
	100.000
Coke, per cent.,	76.940
Color of ash,	Reddish gray.

The percentage of sulphur in the above coal is damagingly high. If, however, it runs on the average lower than as given above, the coal would prove a strong and efficient steam coal.

The *Bloss bed* at Antrim, however, is depended upon for the coal shipped to market. (There is at Antrim *no coal* between the Seymour and the Bloss bed according to Mr. Hardt's section.)

It is given in the section as 5 feet 4 inches thick. It does not, of course, hold this thickness all through the workings, but in many cases runs down very considerably, as might reasonably be expected. It has proved, however, to be a reliable and profitable bed, as persistent in char-

acter and size as the same bed at other places in the basin.*

A specimen of the fair average of the run of the mine of the Bloss bed at Antrim, representing all the benches together, just as the coal goes to market, was forwarded for analysis, and yielded (McCreath):

The coal has a deep black lustre generally, with seams of bright crystalline coal running through it. It is rather tender, is free from slaty coal, and carries only a small amount of iron pyrites.

Water,	2.260
Volatile matter,	20.240
Fixed carbon,	71.847
Sulphur,	.548
Ash,	5.105
	100.000
Coke, per cent.,	77.50
Color of ash,	Gray.

The above analysis represents a coal of most superior character; low in ash, low in sulphur, and with every requisite for a most efficient and valuable fuel.

The percentage of combined water runs curiously higher than the average of specimens of Bloss coal mined in this basin.

West of Wilson's Creek

West of Antrim is Wilson's Creek, a large stream which cuts down 600 to 700 feet below the hill tops which hold the coals.

Coal has been opened up and is now worked on the West side of Wilson's Creek, opposite to Antrim; and the Bloss bed on the west side appears to be fully 30 to 40 feet higher than the level of the same bed at Antrim.

* A rounded white quartz pebble, 3½ inches by 2½ inches in size, smooth and waterworn, was found in the Antrim Mine on the Bloss bed, by John Prothero, miner, May, 1878. The specimen was given to Mr. James MacFarlane, of Towanda, who has presented it to the Survey Collection at Harrisburg.

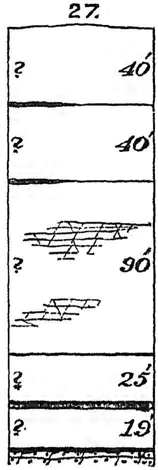
The curious feature is that this large stone was found in solid coal, near the top of the bed. No slate nor wash was near it, but the specimen itself shows that it was in coal, the irregularities on its surface being now filled with pure coal.

In view of the nature of the vegetable growth from which coal was formed, the presence of this large pebble entirely alone, close packed into pure coal, is very noteworthy.

There is no railroad communication at present to afford an outlet to market for any coal west of Wilson's Creek: but some few mines are opened, and one or two thousand tons of coal are mined yearly and hauled away, mainly on sleds in winter, for use in Wellsboro' and the adjacent country.

The region is entirely undeveloped, except these few openings; and it is, therefore, impossible from surface examination, to obtain more than a very incomplete section of the measures as they exist on the west side of Wilson's Creek.

The vertical section as obtained near Bache's mines, 10 miles south of Wellsboro', Tioga county, is as follows:



Hill top,	—
Concealed,	40' 0"
Bench *coal*, rep'ted once opened.	
Concealed,	40' 0"
Coal, once opened, reported as having yielded 2 feet of good coal.	
Concealed, (clearly much sandstone,)	90'
Coal,	0' 8"
Concealed,	25' 0"
Coal, (Bloss bed, Bache Mine,)	3' 4"
Concealed,	—
Bear Creek *coal*, reported 19 feet below the Bloss bed, and showing 2 feet thick, (at Mitchell's, one mile away,)	21' 0"
Massive congl'm'ate SS.,	—
Total,	220' 0"

The above imperfect section was the best which could be made without special development for the purpose; but it is sufficient to show that the measures of Arnot and Antrim cross Wilson's Creek and continue to the West of it. The Blossburg Coal basin, therefore, runs from Fall Brook on the East to where the basin points out some 1 or 2 miles ± west of Bache's mine.

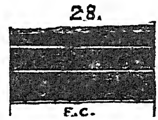
None of the coal beds of the above section are opened up for examination, except the *Bloss bed.*

At the *Bache mine* the coal is worked for local supply.

The mine runs in South 50° West, and the workings are carried to the South, the coal rising in that direction.

The coal measures in the mine as follows:

Roof, black slate,	—
Coal,	8″ to 0′ 10″
Slate parting, persistent,	1″ to 0′ 1½″
Coal,	1′ 0 ′
Slate parting, persistent,	0′ 1½″
Coal,	1′ 5 ″
Bone coal and slate,	0′ 2 ″
Fireclay floor,	—



In working this coal, some of it is hard, breaking up into blocks, while the balance of the coal is only moderately compact.

These coals were analyzed separately.

The hard coal from the Bache mine yielded on analysis (McCreath):

The coal is considerably coated with an orange yellow silt, is unusually firm and compact, and has a deep black lustre on clean fracture. It shows numerous thin partings of mineral charcoal, and has a decided tendency to break up into blocks.

Water,	2.380
Volatile matter,	20.005
Fixed carbon,	70.055
Sulphur,	.565
Ash,	6.995
	100.000
Coke, per cent.,	77.615
Color of ash,	Reddish gray.

The softer coal from the Bache mine yielded on analysis (McCreath):

The coal, clean looking generally, has a deep black lustre. It is moderately firm and compact, and shows numerous thin partings of mineral charcoal. It breaks with irregular fracture.

Water,	2.240
Volatile matter,	20.045
Fixed carbon,	70.357
Sulphur,	.588
Ash,	6.770
	100.000
Coke, per cent.,	77.715
Color of ash,	Gray, with red tinge.

These coals from the Bache mine, therefore, though so

unlike in appearance and physical structure, are almost perfectly identical in chemical composition.

If the analyses of the specimens forwarded from the mine will represent what would be afforded as an average of extensive workings, the coal of the Bloss bed west of Wilson's Creek is fully equal to any coal from the same bed now worked in the Blossburg Coal Basin.

About one mile North-east from the Bache mine, the *Bloss bed* is opened and worked at *Mitchell's mine*, on the west bank of Wilson's Creek, opposite to the Antrim mines.

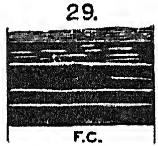
The mine is worked on a small scale, only to supply one or two thousand tons for local use. It has no railroad communication, and its yield is hauled away on wagons and sleds.

The Bloss bed here makes a beautifully defined bench around the hill sides.

The mine runs in North 10° West, and where measured the coal shows thus:

The drift has been run in far enough to secure clean, bright, hard coal, with good roof and floor: and some fair average specimens were taken from the run of mine coal, as it is now shipped from the mine, and forwarded to the Laboratory of the survey at Harrisburg. They yielded on analysis (McCreath):

29.



Roof, black slate,	—
Coal, somewhat bony in places,	0′ 10′
Slate parting,	2″ to 0′ 3″
Coal,	1′ 0′
Slate parting,	2″ to 0′ 3″
Coal,	0′ 6′
Slate,	½″ to 0′ 1″
Coal,	0′ 11″
Fireclay floor,	—

The coal is bright and compact, with much mineral charcoal.

The coal, considerably coated with silt, has a dull dead lustre on fresh fracture. It is generally compact, carries numerous thin partings of mineral charcoal, and seems in the main free from iron pyrites.

Water,	1.810
Volatile matter,	20.350
Fixed carbon,	68.126
Sulphur,	.569
Ash,	9.145
	100.000
Coke, per cent.,	77.84
Color of ash,	Reddish gray.

The analysis shows that the Mitchell and Bache coals are almost identical in composition. The former carries a little more ash in this analysis, but such slight variation is due most probably to the specimen selected, and not to any permanent change in the character of the coal at the Mitchell mine.

It fully equals the average character of the coal mined from the Bloss bed, throughout the Blossburg coal basin, and is of, at least, the average thickness also.

The coal at these mines is screened for use, the lump coal only being used, and most of the fine coal thrown away. No attempt has ever been made to coke this slack.

The *Bear Creek coal* is reported to have been shafted down to at the Mitchell mine and to have been found 19 feet below the Bloss bed 2 feet thick and of good character.

It is not now open and could not be examined at the time (November, 1877).

Various other test openings have been made in the region lying south-west, and south of the Bache mine. In the absence of a complete detailed survey of the region and with incomplete openings, it would be difficult to identify which coal bed had been touched in each case, nor is it needful to do so.

Clearly the Lower Productive Coal Measures, not in whole thickness, but in part, occupy a narrow basin west of Wilson's creek for an area of apparently of about 1 mile across from north to south and about 1¾ miles from east to west.

around the basin in a well defined line, making in many places along the south line a clearly marked cliff wall, and also plainly showing on the north line.

Within these limits of the conglomerate the Lower Productive Coals are present, but in some parts only the lowest coal beds are included.

When the Bloss bed comes to daylight on the north outcrop of the basin, it is as a bed of fully as great size as at Bache's mine, or greater; but the coal is more friable and columnar, and breaks up so much in mining as to afford but little lump coal, most of it coming out as fine coal.

The opening on the north crop is fully one hundred feet higher than the south outcrop of the Bloss bed. The south crop has only been touched in a trial pit, and no accurate measurement of the bed could be made.

The conglomerate of XII shows along the south rim of the basin as a massive gray sandstone, filled with pebbles of rounded quartz, mostly pea sized. It seemed to be dipping quite decidedly to the N. 20° W ±; probably the rocks had slipped slightly and had exaggerated the dip, which should not be so great.

The north dip on the south side of the basin, however, is apparently much steeper than the south dip on the north side of the basin.

These coal openings are 10 miles from Wellsboro, which is their nearest railroad connection.

The basin appears to point out sharply to the west, and no coal is opened in the hills to the westward of the district described above.

CHAPTER XIII.

Character and Uses of the Blossburg Coal.

The analyses of the coals and cokes of the Blossburg Coal Basin have been given in connection with the detailed report upon the different places now working coal in the region.

For convenience of reference in comparing character, the analyses are grouped below under the headings of the different coal beds. It should be stated that taking large quantities for an average, all the coal from the Bloss bed shipped may be said to be closely alike, no matter from which mines it may have been extracted; extra care in mining, picking slate, &c., of course making some difference in forming a reputation among consumers of the fuel.

Any great variation in a single analysis, therefore, may be taken as due to an imperfect specimen; the enormous percentage of sulphur in one analysis of Seymour coal being clearly due to iron pyrites which was hidden in the block, and never discovered until the coal was ground up in the laboratory. The tables of analyses must be considered for general averages, any single analysis having but slight weight, and indeed such analysis must be entirely cast out from the scale whenever it comes in contact with a well established general average, founded upon numerous analyses agreeing well with each other.

Table of Analyses of Blossburg Coals.

"Seymour Coal Bed."

No. 1. Fall Brook.
No. 2. Morris Run.
No. 3. Arnot.
No. 4. Antrim.

	1.	2.	3.	4.
Water,	1.970	.950	1 180	1.460
Volatile matter,	20.105	19.830	21.586	20 600
Fixed carbon,	68.360	60.759	71.574	65.120
Sulphur,	1.795	6.856	.907	2.820
Ash,	7.770	11.605	4 753	9 000
	100.00	100.00	100 00	100.00
Coke per cent.,	77.925	79.22	77.234	76.940
Color of ash,	Lilac.	Deep pink.	Reddish gray.	Reddish gray.

"*Monkey Coal Bed.*"

From Fall Brook opening:

Water,	1.560
Volatile matter,	20.740
Fixed carbon,	66.587
Sulphur,	.773
Ash,	10.340
	100.000
Coke per cent.,	77.700
Color of ash,	Reddish gray.

"*Dirty Coal Bed.*"

From Fall Brook opening:

Water,	2.820
Volatile matter,	17.975
Fixed carbon,	71.326
Sulphur,	.634
Ash,	7.245
	100.000
Coke per cent.,	79.205
Color of ash,	Reddish gray.

"*Bloss Coal Bed.*"

No. 1. Fall Brook.
No. 2. Morris Run.
No. 3. Arnot. Upper bench.
No. 4. Arnot. Middle bench.
No. 5. Arnot. Lower (or main) bench.
No. 6. Antrim.
No. 7. Bache Mine—West of Wilson's Creek.
No. 8. Mitchell Mine—West of Wilson's Creek.

	1.	2.	3.	4.	5.	6.	7.	8.
Water, ...	1.050	1.120	1.190	.940	1.110	2.260	2.240	1.810
Volatile matter,	18.540	18.570	20.735	20.640	18.790	20.240	20.045	20.350
Fixed carbon, .	69.934	72.097	71.697	64.306	63.428	71.847	70.357	68.126
Sulphur, . .	.661	.583	1.023	.914	.602	.548	.588	.569
Ash, ...	9.815	7.630	5.335	13.200	16.070	5.105	6.770	9.145
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke per cent.,	80.41	80.33	78.055	78.420	80.100	77.50	77.715	77.84
Color of ash, . .	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray red tinge.	Reddish gray.

"Bear Creek Coal Bed."

From Fall Brook opening:

Water, ...	.790
Volatile matter, ...	20.965
Fixed carbon, ...	65.465
Sulphur, ...	.725
Ash, ...	12.055
	100.000
Coke, per cent., ...	78.225
Color of ash, ...	gray.

Cokes from Blossburg Coals.

No. 1. Arnot. Bloss Vein coal. North Drift.
No. 2. Arnot. Bloss Vein coal.
No. 3. Arnot. Bloss Vein, fine coal from screening.
No. 4. Arnot. Seymour Vein coal.

	1.	2.	3.	4.
Water, ...	.590	.240	1.150	.220
Vol. matter, . .	.845	.572	1.732	.625
Fixed carbon, .	83.371	83.922	80.927	90.650
Sulphur, ...	.644	.679	.764	.850
Ash, ...	14.550	14.587	15.427	7.655
	100.000	100.000	100.000	100.000
Color of ash, . .	Gray.	Gray.	Reddish gray.	Gray with reddish tinge.

Numerous analyses of the Blossburg Coals have been made at different times for the Fall Brook Coal Company. These analyses are furnished for publication by Mr. A. Hardt, Chief Engineer of the Company, and are reproduced

below for the purpose of showing more completely the general average character of the "Bloss Coal."

Analysis of Fall Brook Coals in 1859 by Prof. Silliman :

No. 1 Drift. Bloss Vein.

Moisture expelled at 212°,	0.99
Volatile matter at redness,	17.23
Carbon,	76.01
Ash,	5.78
	100.00
Coke,	87 per cent.

No. 3 Drift, (Bloss Vein,) 3 samples.

	a.	b.	c.
Moisture,	0.96	1.08	1.12
Volat. matter,	18.04	17.36	18.92
Carbon,	76.55	72.86	74.61
Ash,	4.45	8 70	5.35
	100.00	100 00	100.00
Coke,	84 per cent.	82 per cent.	80 per cent.

No. 1 a Drift, (Seymour Vein,) 3 samples.

	a.	b.	c.
Moisture,	0.91	0.92	0.91
Gas,	17.77	15.62	16.65
Carbon,	72.92	65.86	73.49
Ash,	8.40	17.60	8.95
	100.00	100.00	100.00
Coke,	81 per cent.	83 per cent.	82 per cent.

Analyses, made Aug. 1874, by Hugh Hamilton, Harrisburg, Penn'a.

	Bloss. V., Antrim. Drift No. 1.	Bloss. V., Antrim, Drift No. 2.	Seymour V., Antrim.	Bear Creek V., Fall Brook.	Bloss. Vein, Fall Brook. No. 3 Drift.	Bloss. Vein, Fall Brook. No. 2 Drift.
Moisture,	0.65	0.72	0.80	0.47	0.45	0.47
Volatile matters,	21.65	20.68	24.47	21.35	19.40	17.78
Fixed Carbon,	73.40	74.63	70.63	68.45	69.67	68.42
Ash,	4.30	3.97	4.10	9.73	10.48	13.33
Sulphur,	0.29	0.50	0.39	0.20	0.31	0.35
Coke,	77.70	78.60	74.73	78.18	80.15	81.75

Analyses by J. B. Britton, March, 1877.

	Moisture.	Volatile matter.	Ash.	Fixed carbon.	Sulphur.	Coke.	Sulphur in 100 parts of the coke.
Antrim No. 1, (Bloss V.,)	1.63	18.38	4.73	75.26	0.511	79.99	0.397
Antrim No. 2, (Bloss V.,)	1.46	18.73	6.21	73.60	0.522	79.81	0.549
Antrim Seymour Vein,	1.27	21.10	6.84	70.79	2.209	77.63	1.715
Fall Brook No. 2, (Bl. V.,)	1.07	21.64	11.47	65.82	0.754	77.29	0.550
Fall Brook No. 3, (Bl. V.,)	1.05	17.94	7.71	73.30	0.686	81.01	0.651

In discussing the character and uses of Blossburg Coal it must be understood that by that name, at present, is only meant the coal from the "Bloss bed," inasmuch as that bed alone supplies nearly all the coal which comes to market from the basin. The detailed report has shown the number, thickness, and character of the other coal beds, and thus enabled them to be compared to the Bloss bed coal; but the present discussion of Blossburg Coal is confined entirely to the coal from the great bed of the region—the Bloss bed.

In any examination of the character of a steam coal, the first reference is to the Report of Prof. Walter R. Johnson to the U. S. Navy Department, in 1844. No careful statistics upon the subject had preceded this Report, and so thoroughly and exhaustively was it made that now (35 years after the experiments) it stands as authority upon the subject.

Since that day there have been great changes in the practical relationship of the coals to the market. For example, the Clearfield Coal Region in Pennsylvania, which was then without connection with market, and could not even be tested, now ships (1877) annually about one and a quarter million of tons of coal, or nearly as much as the Cumberland Region in Maryland. The Richmond, Virginia, coals, which were then considered as of much importance have, for various reasons, dropped so steadily behind, that they may be now omitted from any list of steam coals, which deals only with the chief producing regions.

Prof. Johnson's tables show broadly the relationship between the character of a coal as shown by its analysis, with its total evaporative power, its rapidity of action, its efficiency within specified times, &c., &c.

In MacFarlane's Coal Regions of America these results have been conveniently grouped and the table below is reproduced from that work.

Results of United States Government Experiments in Burning Coal under a steam boiler.

ANTHRACITES.

	ANALYSES.				EFFICIENCY.				
	Specific gravity.	Volatile combustible matter.	Fixed carbon.	Earthy matter.	Hours to bring boiler to steady action.	Cubic feet water evaporated per hour during steady action.	Pounds steam to one pound coal from initial temperature.	Pounds steam to one pound coal from 212°.	Steam from 212° from one pound combustible matter.
Beaver Meadow, ...	1.610	2.38	88.94	7.11	3.87	12.57	8.20	9 21	10.462
Beaver Meadow, ...	1.557	2.66	91.47	5.15	2.42	10.66	6.76	9.88	10.592
Forest Improvement, . .	1.477	3.07	90.75	4.41	3.32	12.89	8.92	10.06	10.807
Peach Mountain, ...	1.464	2.96	89.02	6.13	3.54	14.04	8.96	10.11	10.871
Lehigh, ...	1.590	5.28	89.15	5.56	3.27	11.63	7.73	8 93	9.626
Lackawanna, ...	1.421	3.91	87.74	6.35	2.67	11.92	8.56	9 79	10.764
Lykens Valley, ...	1.389	6.88	83.84	9.25	2.63	12.89	8.43	9.46	10.788
Beaver Meadow, ...	. . .	. .		8.10	5.08	9.42	7.86	9.08	9.881
Average, ...	1.501	3.877	88.70	8.51	3.35	10.67	8.43	7.07	10.473
SEMI-BITUMINOUS.									
N. Y. and M. Mining Co.,	1.431	12.31	73.50	12.40	1.33	12.79	8.65	9.78	11.208
Neff's Cumberland, . .	1.337	12.67	71.53	10.34	1.68	14.80	8.19	9.44	10.604
Easby's, Maryland, .	1.307	14.98	76.26	8.08	1.75	12.73	8.88	10.02	10.935
Atkinson & Templeton's.	1.313	15.53	76.69	7.33	0.99	15.70	9.47	10.70	11.624
Early's & Smith's, ...	1.332	15.52	71.29	9.30	1.52	14.97	8.67	9.96	11.034
Cumberland, Navy Yard.	1.414	14.87	70.85	14.98					
Dauphin & Susquehanna,	1.443	13.82	74.24	11.49	0.83	13.35	8.31	9.34	11.171
Blossburg, ...	1.324	14.78	73.11	10.77	0 84	13.67	8.64	9.72	10.956
Lycoming Creek, . . .	1.388	13.84	71.53	13.96	1.72	12.13	7.92	8.91	10.724
Quin's Run, ...	1.331	17.97	72.79	8.41	0.75	13.90	9.08	10.27	11.275
Average, ...	1.362	14.62	73.78	10.70	1.26	14.00	8.83	9.68	11.059
BITUMINOUS.									
Karthaus, Penna., . . .	1.284	19.53	73.77	7.00	1.87	12.48	7.92	9.09	9.887
Cambria Co., Penna., . .	1.407	20.52	60.37	9.15	2.00	12.47	8.04	9.24	10.239
Picton, Nova Scotia, . .	1.318	27.83	56.98	13.39	0.94	12.79	7.48	8.41	9.710
Sidney, Nova Scotia, . .	1.338	23.81	67.57	5.49	1.18	13.85	7.01	7.99	8.497
Picton, Cunard, ...	1.325	25.97	60.74	12.51	0.85	16.47	7.45	8.48	9.648
Liverpool, England, . .	1.262	39.96	54.90	4.62	0.86	13.43	6.95	7.48	8.255
Newcastle, England, . .	1.257	35.83	57.00	5.40	0.84	13.75	7.68	8.66	9.178
Scotch, ...	1.519	30.19	48.81	9.34	0.96	14.32	6.14	6.95	7.719
Pittsburg, Penna., . . .	1.252	36.76	54.93	7.07	. . .	10.56	7.03	8.20	8.942
Cannelton, Indiana, . . .	1.273	33.99	58.44	4.97	0.50	15.05	6.31	7.34	7.734
Average, ...	1.3235	30.339	60.301	7.894	1.11	13.51	7.20	8.18	8.98

The above table gives the character and efficiency of the Anthracite coals, the Semi-bituminous coals, and the Bituminous coals in sufficient detail. The composition of the

Blossburg coals is given in the tables of analyses already compiled in this chapter.

The remaining great steam coal, the Clearfield coal, is shown by the complete table of analyses below. They are taken from the Report of 1874.*

By comparing these analyses and applying to them, according to their analyses, the efficiency of the coals in Johnson's table with which their analysis most closely corresponds, a close approximation to their efficiency as a steam raising fuel can easily be obtained.

Table of analyses of Steam Coals from Clearfield County, Penna.

No.	Water.	Volatile Matter.	Fixed Carbon.	Sulphur.	Ash.
1.	0.81	20.640	74.023	0 507	4.02
2.	0.67	21.360	74.284	0 435	3.251
3.	0.78	21.680	73 052	0.688	3.80
4.	0.71	23.400	72 218	0.532	3.14
5.	0.765	20.090	74.779	0 666	3.70
6.	1.10	23.070	71.199	0.611	4.02
Average, ...	0.806	21.707	73.259	0.573	3.655

These coals above given are from mines near Houtzdale, on the Beaver branch of the Moshannon, and represent the largest producing mines in the Clearfield steam coal region.

In the "Coal Regions of America,"† Mr. MacFarlane has discussed the Blossburg coals especially with reference to their use as blacksmith and steam coal. A part of this discussion, including his extract from Prof. Johnson, is reproduced below as embracing what is needed for a clear understanding of the position of the Blossburg coals.

"*Semi-bituminous coal*, in the sense in which we shall use the term to distinguish it from common bituminous coal, is that peculiar kind produced in the regions mentioned, which, while it yields coke and combustible gases,

*Report H. Second Geological Survey of Penn. 1874.

† Coal Regions of America, by James MacFarlane, Ph. D.

yet contains only 11 or 12, and always less than 18 per cent. of volatile combustible matter, and not less than about 70 per cent., and never more than 84 per cent. of carbon.

Whatever may be its useful qualities, it must be confessed it is in mere appearance inferior looking to almost any other kind of coal. As it comes from the mine, or in technical phrase, "the run of the mines," it consists of at least from one-third to one-half of fine coal, or what English miners call "dead-small," and some of it may be called dust. The large or lump coal is black, shining, and much more easily broken than anthracite, falling into irregular-sided cubical pieces, the cleavage being very much the same in a cross fracture as in the plane of stratification. It seldom cleaves into smooth, perfect cubical blocks of any size, like the Pittsburgh coal. It is decidedly dirty, cannot be touched without soiling the hands, and its whole merit and value consist in its useful qualities.

* * * It has a wider range in its use than any other kind of coal. For blacksmithing, for puddling and heating in rolling mills, and for steam, all kinds of coal are used, just as all sorts, however unsuitable or inferior, are to some extent used for household purposes; but the kind of coal which is invariably admitted to be by far the best adapted for the work of the blacksmith, or ironsmith (as he should properly be called), is what we are describing as the semi-bituminous coal. This is mainly owing to its great heating power, and its making what is called in the language of the trade, "a good hollow fire." The fine portions of the coal, which are generally used alone in this work, become adhesive and cemented together in burning into a compact body on the outside; the fire being confined to the interior of the mass, the coal not burning outwardly, but only around the iron which the smith is heating, and forming an arch lined with burning coals, into which the iron is thrust, while the outside presents no appearance of fire. This is not only a more economical fire, burning the coal only where it is needed, and protecting the workman from the heat of an outside blazing fire, which is so objection-

able, particularly in hot weather, but it makes a hotter fire by concentrating the heat in the interior, directly in contact with the iron, where it is needed.

In addition to this these semi-bituminous coals possess the very valuable quality, so indispensable for this work, and so important in all uses, of being free from sulphur. The great importance of this is but little appreciated in the Eastern States. As so much of the coal produced throughout the great Allegheny coal region is of good quality, we are only enabled properly to estimate its real excellence and its great purity after witnessing the masses of sulphuret of iron brought out of the mines with the coal, and much of it adhering to it and sold as coal in the States of Michigan, Illinois, and Missouri. For smithing, or for any work connected with the manufacture or use of iron, nothing is more injurious. In the New York, Philadelphia, Baltimore, Boston, and other Atlantic markets, no other coal is sold or used for blacksmithing but Cumberland, Clearfield, and Broad Top; while in the interior of the State of New York, in western Canada, or in all the Western or Northwestern States, every blacksmith uses Blossburg coal, which is the generic name by which all this kind of coal from northern Pennsylvania is called. As an instance of the distance to which this valuable fuel is carried, it may be stated that 75,053 tons were shipped in 1871 from Oswego and Buffalo to Canada and our own Western States. Chicago alone took 21,248 tons before the great fire, and had an insufficient supply, much of which was resold as far as Omaha, and shipped still further westward hundreds of miles toward the setting sun. The blacksmiths of Salt Lake City, in Utah, use Blossburg coal, and it is even carried in sacks over the plains and over the mountains, through the gold regions of our far western territories, to sharpen the tools of the miner several thousand miles from Blossburg, where it was mined. This is owing not to the absolute want of other coal, but to the western coal not possessing those peculiar qualities before described required for this business.

What has been said in regard to blacksmithing applies

to puddling, heating, and rolling mills. This work, however, is not done by a hollow fire, but by the passing over the iron of the heat and flame of the coal, requiring a strong coal of great heating power, burning with a flame so as to diffuse the heat from the furnace where it is burnt over the iron placed in the line of the draught, requiring also a coal free from sulphur and other impurities. All the puddling and heating furnaces from Troy, New York, to Buffalo use Blossburg coal in very large quantities. * * * * * *

There is also the important and useful attribute of this species of coal, which is not often referred to, but which is a high recommendation for its use in blacksmithing, in puddling, and heating in rolling mills, and in generating steam under boilers, giving it an advantage over anthracite. "The hydrogen of the gaseous part of the coal is a potent purifier, or remover of any sulphur with which either the coal itself or the iron may be contaminated. The excellence of the iron of the bituminous black band of Scotland is admitted to be due to the purifying influence of the hydrogen of its bitumen."—*Rogers.*

The superior quality of the wrought iron puddled and heated with semi-bituminous coal is well known, the reason being that the anthracite, unlike the semi-bituminous coal, contains but little hydrogen to form a chemical combination with and carry off the sulphur.

But the largest demand for Blossburg and other semi-bituminous coals is for the *generating of steam* in locomotive and stationary boilers. The qualities required for a good steam coal are various and are not very well understood.

"The question of the value of coals for the purpose of generating steam is, of course, mainly dependent on their heating power; that is, on the weight of water which a given weight of coal, burned under a given evaporating vessel, can convert into steam while undergoing combustion. But this is not the only circumstance requiring investigation, in order to decide their value.

The manner in which it burns, whether with much or little flame; the amount and character of its combustible ingredients; its facility or difficulty of ignition; the per-

fection of the combustion, or the proportion of the whole amount consumed to that of the combustible matter placed upon the grate; the concentration or diffusibility of its heat; the proportion of humidity and that of the sulphur which it may contain, with the consequent liability, under certain circumstances to undergo spontaneous combustion, are all points requiring attentive consideration. In addition to these, we have the question of the manner in which each coal behaves when coming to the temperature of ignition: its tendency to retain its original form; the nature and extent of change when any occurs, whether by simply cracking and disintegrating into angular fragments, or by enlarging the bulk, rounding away and obliterating the angles, and yet not agglutinating mass to mass; or, finally, by wholly changing its form and consistence, swelling to a great degree, and cohering so as to form a nearly continuous roof, and thus impeding the passage of air through the ignited coal. In some cases the question of the amount of solid matter which accompanies the gaseous products of combustion in the state of smoke, becoming soot upon the flues of the apparatus in which the combustion is conducted, is one of great practical importance. Of these incidental questions, the amount and character of the incombustible ingredients of different coals, is a point eminently deserving of notice. It indicates the deduction which must, in all cases, be made from the heating power of an equal weight of the coal, considered as pure combustible matter; it shows the extent and kind of labor requisite in managing the furnace; it warns us what to expect in regard to durability of grate bars, and the adhesion of scoria to those important appendages of the furnace. All these subjects must necessarially engage the attention of engineers and furnace-managers, and no little portion of the good or bad character of coal may be considered to depend on these circumstances. The relation of the incombustible ingredients of coal to each other is often such as to render the mixture fusible at the temperature of ordinary furnaces, or at least to be in a certain proportion reduced to a pasty coherent mass upon the grate, impeding the

passage of air, leaving another portion unvitrified, and capable of passing between the interstices between the bars. For different coals the proportion is very different, even when the combustion is conducted as far as practicable in the same manner and with the same intensity of heat."—*Walter R. Johnson.*

The tendency of semi-bituminous coal to melt and cohere so as to form a crust and, in part, impede the passage of air through the coal, might at first view be considered as an objection to its use for steam purposes. But * * * for the proper utilizing of the hydrogen gas given out in burning, a very large quantity of atmospheric air is required, so large that very few furnaces afford a sufficient supply to produce perfect combustion. Now, in burning bituminous coal which has not this melting or caking quality, the hydrogen gas is given out so rapidly, the coal burning altogether outwardly, that for the want of sufficient oxygen much of it passes off unconsumed, and a large part of the heating power of the coal is lost, whereas with the semi-bituminous or caking coal the gas is partially retained by the formation of the crust, and is given out more gradually, the crust acting the part of a temporary gas holder, from which the fireman, with his poker can, as occasion requires, by breaking the crust, allow the gas to escape in such quantities that it may unite with the limited supply of oxygen. This caking quality is very valuable in a locomotive fuel, where the draft is so strong that an adhesive coal is preferred, and it admits of the use of grate-bars with wider air spaces than can be used with other coal that would be liable to fall through the grates, which is attended with a loss of fuel.

"The Superintendent of the United States Armory at Springfield, Massachusetts, has recently been conducting a series of experiments to test the value of certain kinds of coal as steam generators. Each variety of three different classes of coal was used for six consecutive days in raising the steam for the engine of the establishment, with the following reported results: Of the Lackawanna, or hard anthracite, 4.01 pounds per horse power were used per hour; of the Pittston, or softer anthracite, 4.02 pounds were used;

and of the Cumberland or bituminous coal of Maryland, 3.03 pounds were used. At the Springfield Armory, the Lackawanna coal cost $8 50 per gross ton, the Pittston $7 85, and the Cumberland $9 10. From these data it is calculated that the cost, per horse power, is 15 mills for Lackawanna, 14 mills for Pittston, and 12 mills for Cumberland; and it is therefore alleged that bituminous coal is the more economical fuel as a steam-generator, making more heat and creating more power per pound and per cent. of cost than the harder coals.

This has also been done at Colt's Armory in Hartford; and after careful experiments it was found that for steam-generating purposes the Cumberland coal was better and cheaper than the anthracite, whether compared ton for ton or by the relative cost of the two."

Probably there is no better and more succinct statement of the requisites of a good steam coal than is given in the Rogers' Final Report of Pennsylvania Geology. It, of course, embodies all the results of W. R. Johnson's experiments for the Navy Department.

"1. It should possess a high absolute evaporative power.

2. It should, at the same time, as far as is compatible with the foregoing property, kindle readily, and burn with great celerity, generating a large body of steam in a short time.

3. It should be easily managed, and steady in its combustion, and to this end its ashes or earthy matter should tend, as little as possible, to choke the draught of the grate by fusing, even at an extreme heat, into an adhesive clinker.

4. The fuel should be free from any excess of incombustible matter, as this, all other things being the same, will materially impair its efficiency, and its ashes should produce but little clinker.

5. It should be exempt from any considerable amount of sulphur, for this tends to corrode the flues, and is otherwise detrimental.

6. Whatever volatile matters it possesses should not be bituminous, but should be in the condition of the free gases,

susceptible of ignition or disengagement without smoke, and these volatile matters should not exist in any greater amount than will suffice to give rapidity of combustion to the fuel. Any larger proportion is at the expense of its heating power.

7. A fuel should not be too cohesive and refractory on the fire, nor yet too tender and divisible. In the one case its combustion will be slow and irregular, and in the other it will be still slower for the want of the requisite draught. A certain degree of spontaneous frangibility, such as is shared by some of the less-resisting anthracites, and by many of the firmer semi-anthracites, appears from practice and experiment to be the structure best suited to extreme vigor and steadiness of combustion.

8. For certain purposes of domestic consumption, coals should be capable of sustaining a mild and steady combustion, and of remaining ignited at a low temperature with a comparatively feeble draught.

9. For certain uses it is important that a coal should unite with a high evaporative power such a degree of density and structure combined, as will enable it to contain a relatively large amount of carbon in a given space. This capability of being economically stowed or packed away, is a point of daily increasing consideration. The difference between the least and the most stowable anthracites is as much as 16 per cent., and between the closer packing anthracites and the lighter and more open bituminous coals, it even exceeds 20 per cent.

10. It is likewise desirable that a coal should possess sufficient tenacity in the lump, to bear the abrasion incident to its transportation, without serious waste by reduction to fine coal.

These are the principal qualities in coals which materially influence their economical value. No one variety will ever be found to unite them all, for some of them can hardly co-exist in a high degree in the same specimen. The relative worth to be assigned to these several desiderata, is itself variable with the uses to which the fuel is to be applied. But having a specific application in view, it is easy

to ascertain what union of compatible qualities will insure to a coal the highest possible efficiency. This once determined on, the records of judiciously conducted practical experiments will then prove the proper guide in selecting the kinds required."

Classification of Coals.

In classifying the coals of Pennsylvania for the Report of the First Geological Survey, Prof. H. D. Rogers tabulated them thus :

ANTHRACITES,	Hard Anthracite.	
	Semi, or Gaseous Anthracites.	
COMMON BITUMINOUS COALS,	Semi-bituminous Coals,	Semi-bituminous Cherry Coal.
		Semi-bituminous Splint Coal.
	Bituminous Coals,	Caking Coal.
		Cherry Coal.
		Splint Coal.
HYDROGENOUS, OR GAS COALS,	Cannel Coal.	
	Hydrogenous Shaly Coal (Torbanehill, &c.)	
	Asphaltic Coal (Albert mine.)	

Anthracites—Volatile matters below 6 per cent.

Semi-anthracites—Volatile matters below 10 per cent.

Semi-bituminous—Volatile matters between 12 and 18 per cent.

Bituminous—Volatile matters above 18 per cent.

This classification was found convenient for commercial purposes, and has been, therefore, in very general use.

In a paper upon coals,* Prof. P. Frazer, Jr., has pointed out how, in any scientific classification, the consideration of the accidental impurities (the water, ash, and sulphur,) will totally destroy the possibility of grading the coal according to its true rank, that is the proportion of volatile hydrocarbons to fixed carbon.

He cites the following example: "As an illustration of some of the bad effects of such a system (at least for systematic classification) let us suppose that we have a pure coal corresponding to each of the limits which Professor Rogers sets for bituminous coals, viz: 1st. Fixed carbon, 84 per cent., volatile hydrocarbons, 12; that is to say, one part

* Paper read before the American Institute of Mining Engineers by Persifor Frazer, Jr.

of volatile hydrocarbons to 7 parts of fixed carbon. 2nd. Fixed carbon, 52, and volatile hydrocarbons, 48=13:12. If we mix the first of these materials with various weights of impurities, we shall have substances whose constitution is expressed in the following table:

	I.	II.	III.	IV.
Impurities, per cent.,	20	28	36	44
Fixed carbon, per cent.,	70	63	56	49
Volatile hydrocarbons, per cent.,	10	9	8	7

In the second case the table would be:

	I.	II.	III.	IV.
Impurities, per cent.,	0	25	50	75
Fixed carbon, per cent.,	52	39	26	13
Volatile hydrocarbons, per cent.,	48	36	24	12

Yet the *fuel* portion of all the mixtures in the first table is the same, viz: a bituminous coal of the composition C : V—H. C :: 87.5 : 12.5, and that of all the mixture in the second C : V—H. C :: 52 : 48. The foreign impurity is the only item of difference between the analyses of each table."

After alluding to the fact that Walter R. Johnson had (in 1844) adopted the true method by classifying his coals according to the ratio of fixed carbon to volatile combustible matter, Prof. Frazer suggests the following classification:

	$\frac{C}{V—H. C.}$
Hard, dry anthracite,	100 to 12
Semi-anthracite,	12 to 8
Semi-bituminous,	8 to 5
Bituminous,	5 to 0

An average of eight analyses of the Bloss Vein coal from the Blossburg Coal Basin gives the following result:

Water,	1.465
Volatile matter,	19.741
Fixed carbon,	68.974
Sulphur,	.686
Ash,	9.134
	100.000

This may be taken as about fairly representing the Blossburg coal as shipped from the basin.

The coal has always been classed as *semi-bituminous*, and is altogether sold and used as a coal of this class.

Yet it is slightly beyond the limit of volatile hydrocarbons assigned to semi-bituminous coals, taking Prof. Rogers definition that coals are called semi-bituminous when they have anywhere from 12 to 18 per cent. of volatile hydrocarbons, 70 to 84 per cent. of carbon, and the balance water, sulphur, and ash ; and are called bituminous coals whenever they exceed the above percentage of volatile hydrocarbons.

It has been shown above by Prof. Frazer how exceedingly loose and unscientific any definition is which brings in the accidental and varying impurities ; and that scientific classification demands their exclusion.

Yet while scientifically speaking a coal is as much a true coal whether it contains 2 per cent. or 22 per cent. of impurities, yet in a commercial sense, over those regions where a comparatively pure coal is easily obtainable, a coal ceases to be a *coal* when it contains above 15 to 20 per cent. of impurities.

That is, in the language of the business world, coal means *merchantable coal;* and the ash, sulphur, and water, which are, scientifically speaking, mere accidental impurities, are, in the business view, the features of its constitution most carefully to be considered.

To define the true character of the coal more strictly, in leaving out the impurities, the relationship of volatile hydrocarbons to fixed carbon in the Bloss vein coal is 1 to 3.4939.

This ratio differs decidedly from that assigned to the Blossburg coal by Prof. W. R. Johnson. He made the relationship of volatile hydrocarbons to fixed carbon as 1 to 4.946.

There is here a curious discrepancy between the complete and accurate series of analyses of Mr. McCreath and the character of the Blossburg coal as given by Prof. Johnson.

The Blossburg coal, as examined by Prof. Johnson, was mined by the Arbon Coal Company, at Blossburg, from a three foot coal bed; was mined in January and packed for shipment May 12, between these dates lying exposed. It yielded on analysis:

Moisture,	1.339
Sulphur,	0.853
Other volatile matter,	13.927
Earthy matter,	10.773
Fixed carbon,	73.108
	100.000

This doubtless represented fairly the character the character of the coal from the Blossburg mine of the Arbon Company.

But all the analyses made by Mr. McCreath of the coals from Fall Brook, Morris Run, Arnot, and Antrim agree closely with each other. The variations in character are trifling, and the average of them all is to give the Blossburg coal, as stated above, an average of volatile hydrocarbons to fixed carbon of 1 to 3.4939.

Far more surprising than the discrepancy noted above is the record of an analysis, by Prof. Walter R. Johnson, of the "Bear Creek, Blossburg" coal. It is in the table of analyses of the Roger's Final Report of Pennsylvania.

The analysis shows:

Coal columnar, somewhat compact, thin seams of charcoal, lustre jet black.

Vol. matter in 100 parts,	32.00
Fixed carbon, do. do.	68.00
Earthy matter, do. do.	5.20

Taking the volatile matters (which presumably include the water and sulphur, and thus injure the accuracy of the result) and the fixed carbon (32:68) the proportion stands as 1 to 2.125.

By comparing these two widely divergent analyses of Prof. Johnson with the comparatively complete and very closely agreeing sett of analyses of Mr. McCreath, it is

easy to see how great may be the injustice and error in reasoning as to average character over considerable areas by any single analysis of one specimen.

Prof. Johnson's analyses were doubtless perfectly accurate of the specimens sent to him, yet neither of them gave anything like a fair judgment of what is really the Blossburg coal as it now goes to market.

The statistics of the coal production of the Blossburg, McIntyre, and Barclay mines for the years 1871–1877 are thus given by James Macfarlane, Esq., the General Agent of these united companies :

Annual Production of Semi-Bituminous Coal in Northern Pennsylvania, for seven years, in Tioga, Bradford, and Lycoming Counties, Pa. Compiled by James Macfarlane, Esq.

Years.	Tioga County.			Lycoming County.	Bradford County.			Total annual production.
	Fall Brook Coal Company.	Morris Run Coal Mining Company.	Blossburg Coal Company.	McIntyre Coal Company.	Schrader Coal Company.	Towanda Coal Company.	Fall Creek Bit. Coal Company.	
1871, ...	232,632	385,994	196,453	106,130	. . . .	249,240	129,090	1,299,544
1872, ...	233,694	318,079	297,489	171,427	. . . .	263,960	118,882	1,403,531
1873, ...	312,466	357,384	321,207	212,462	. . . .	252,329	85,315	1,541,163
1874, ...	258,192	249,438	255,086	138,907	100,219	215,572	21,281	1,238,695
1875, ...	190,347	164,506	226,420	164,504	157,686	200,424	18,529	1,122,416
1876, ...	217,347	197,698	201,939	208,701	200,795	160,343	. . . . . .	1,186,823
1877, ...	199,510	181,001	221,734	183,715	175,757	164,344	. . . . . .	1,126,061
	1,644,188	1,854,100	1,720,328	1,185,846	634,457	1,506,212	373,102	8,918,233

The following table shows the shipments of Clearfield Co. (Penn.) coal for the years 1873–1877. The statistics are furnished by Mr. Shillingford, Secretary of the Kittanning Coal Company:

1873,	612,075	net tons.
1874,	665,214	"
1875,	927,867	"
1876,	1,218,861	"
1877,	1,372,153	"

While this enormous trade in Clearfield coal has been growing with such rapid strides, the Cumberland (Maryland) coal region has steadily decreased its shipments, from 2,674,101 gross tons in 1873 to 1,574,339 gross tons in 1877. Local causes, strikes, and disputes concerning shipment rates have contributed to this decreased shipment from the Cumberland Basin; and while this has of course assisted the Clearfield trade, yet the chief reason for the increase of tonnage is the extraordinary cheapness with which clean coal can be put upon the cars in the Houtzdale region.

Blossburg Coke.

The analyses of cokes made at Arnot are given on page 183, and the description of their appearance and strength on page 185.

A number of years ago some partial and probably unskilled attempts were made to coke the Bloss coal. The result was a failure; and for many years it seemed to be agreed that nothing could be done successfully in the way of coking it.

The recent experiments made at Arnot have demonstrated that the slack coal, coked in the Beehive Oven, for 48 hours, watered in the oven, &c., as is customary in the Connellsville region, will produce a firm, coherent, ringing coke, of excellent character, and strong enough to bear the burden in a furnace stack of 60 feet in height.

Already more coking ovens are being built at Arnot; and it is doubtless only the commencement of a large and permanent trade in coke for the supply of New York State.

In connection with the question of coking, the analyses

of the coals, as given in the detailed report, bear upon the percentages of sulphur volatilized in coking.

Considerable attention has been given to this question, and it has been maintained usually that the *condition* of the sulphur in the coal was the important factor — that "free sulphur" would nearly all pass off in coking, while sulphur combined with iron would remain in the coke.

A laboratory coking of Barclay coal gave :

Sulphur taken up by iron,	.192
Free sulphur,	.584
Sulphur volatilized by coking,	27.190 per cent.
Volatile matter in coal,	17.110

A laboratory analysis of some Seymour Vein coal gave :

Sulphur taken up by iron,	6.352
Free sulphur,	.504
Sulphur volatilized by coking,	35.15 per cent.
Volatile matter in coal,	19.830

Another analysis of laboratory coke from the Seymour Vein coal gave :

Sulphur taken up by iron,	1.007
Free sulphur,	.788
Sulphur volatilized by coking,	31.92 per cent.
Volatile matter in coal,	20.105

A laboratory coke from Bloss Vein coal gave :

Sulphur taken up by iron,	.152
Free sulphur,	.431
Sulphur volatilized by coking,	14.750 per cent.
Volatile matter in coal,	18.570

Another laboratory analysis of Bloss Vein coal gave :

Sulphur taken up by iron,	.152
Free sulphur,	.409
Sulphur volatilized by coking,	15.12 per cent.
Volatile matter in coal,	18.540

A laboratory coke made from Bear Creek coal gave :

Sulphur taken up by iron,	.280
Free sulphur,	.445
Sulphur volatilized by coking,	27.44 per cent.
Volatile matter in coal,	20.965

It will immediately be seen how utterly these analyses disagree with any theory ot the volatilization of all, or nearly all, the "free sulphur" by coking.

In the first analysis, with 75 per cent. of the sulphur as "Free Sulphur," and 25 per cent. of sulphur combined with iron, 27.19 per cent. of sulphur were volatilized.

In the second case, with only 7 per cent. "Free Sulphur" and 93 per cent. sulphur with iron, 30.15 per cent. of sulphur were volatilized.

In the third case, with 44 per cent. "Free" and 56 per cent. with iron, the volatilization was 31.92 per cent.

In the fourth case, with 74 per cent. "Free" and 26 per cent. with iron, the volatilization was 14.75 per cent.

In the fifth case, with 73 per cent. "Free" and 27 per cent with iron, the volatilization was 15.12 per cent.

In the sixth case, with 61 per cent. "Free" and 39 per cent with iron, the volatilization was 27.44 per cent.

Thus more than twice the percentage of sulphur was volatilized from a coal holding only 7 per cent. of "Free Sulphur" than from a coal holding 74 per cent. of "Free Sulphur." In the face of such figures it is impossible to cling to any theory of volatilizable free sulphur; and it seems as though the condition of the sulphur in the coal could be of no possible consequence in informing us what would be the percentage of sulphur to be driven off in coking.

Although there has not yet been gathered sufficient facts to warrant any definite opinions upon the subject, yet the general tendency of them all is to point to a relationship between the percentage of volatile matter and the percentage of sulphur expelled in coking.

In the numerous coke and coal analyses which have been given in previous reports, where the general average of the volatile matter of the coal was 30 to 35 per cent., the average volatilization of sulphur in coking averaged fully 35 per cent., whether in laboratory tests or in practical coking in large quantities in Beehive Ovens.

The average percentage of volatile matters of the coals just named above is 19.18; and the average percentage of sulphur volatilized in coking is 24.43.

Chapter XIV.

The Gaines Coal Basin in Tioga County and on Pine Creek in Potter County.

It has been the prevalent opinion for many years that no coal, or very little, existed in Tioga county except in the synclinal axis of the Blossburg Coal Basin.

This is clearly an error, for coal beds of the Lower Productive Measures are now opened and worked in Gaines township, Tioga county, in the next great synclinal north of the Blossburg Basin, from which it is separated by a broad anticlinal valley.

The exact course of the "Gaines Basin" is thus described by Mr. Sherwood, who has carefully followed out the anticlinals and synclinals of Tioga and Bradford counties.

* * * "Its centre line enters Tioga from Bradford county, near the southeast corner of Jackson township; crosses Tioga River at the mouth of Mill Creek; Crooked Creek, near Potter's Hotel; and enters Potter county on the north side of Pine Creek. At the line between Tioga and Rutland townships this basin, on its highest knobs, catches the Millstone grit, which is the foundation or "bottom rock" of the true coal measures. This rock possesses very marked characters of its own, which serve to distinguish it from every other bed. At some points in this basin it contains pebbles of quartz; at others it is a hard, white, quartzose sandstone, excellent for the manufacture of glass, and having a very uniform thickness of about thirty feet. The hills have suffered such erosion from the waters of the Tioga, Mill Creek, Crooked Creek and tributaries, that we do not meet with this rock again on going west until after

we cross Norris Brook, west of Niles Valley, where it again caps the hills. But here the basin begins to widen and deepen to the southwest, so that on reaching "the barrens" at Long Run, instead of capping the hills, it is low enough to be itself capped by over one hundred and ninety feet of coal measures."

As above stated, the coal measures first catch in this basin in the vicinity of Long Run, Gaines township.

When this region was examined (November, 1877,) it was not opened up in such a manner as to afford a complete vertical section of the measures and a special examinations of all of the coal beds.

The region had been opened up a year before for a private examination by Mr. Sherwood, who reported the facts to the owners. These openings could not be seen and measured, except in part, when examined in November, and Mr. Sherwood's statements will therefore be re-produced in this chapter, concerning facts observed by him in his survey.

In the centre of the basin, where the highest geological measures are caught, a sandstone, thin bedded usually and much current bedded, 35′ thick, makes the hill crest.

Under it comes the upper Coal bed, called the "*Hurd Coal bed*" locally; it was mined many years ago, but the opening is now closed. It is *reported* to have yielded 22 inches of coal of good character, having been worked to a considerable extent and hauled many miles for blackmith's use.

But it could not be measured, nor could any specimens be procured for analysis, to show its character.

The next coal opened below the Hurd Coal, called locally the "*Knox & Billings*" coal, is the bed now mined for local use in the region.

There would seem to be about 20 feet of interval rock between the two beds, slates and shales. In the absence of opportunity to examine the Hurd Coal it seemed at first as though the two beds might be identical, but there is apparently a difference in covering rocks which justifies their separation by about 20 feet of interval.

A mine is opened on the *Knox & Billings* Coal bed, 2 miles from Gaines P. O.

The coal is picked or blasted down from roof to floor clean. It has no regular and persistent slate parting. Some irregular small lenticular masses of slate show in the bed.

Where examined, fully 100 yards in under cover, the coal was yet rusty, apparently from roof cracks, the rust and infiltered clay showing on the butt-face.

Though the coal is tolerably compact yet it breaks up a great deal in mining. It is cuboidal, with but little mineral charcoal, only a small show of pyrites, and jet black on fresh fracture.

The average thickness of clean coal from roof to floor, where measured, was about 3 feet. It is said to run from that up, sometimes considerably larger. But 3 feet to 3½ feet is probably a fair average, or 5000 tons to the acre, taking broad areas in question.

The coal is much used locally by blacksmiths, and is hauled many miles for the purpose. It makes a hollow fire, with great heat; any welding can be done by it, and it holds fire well in the forge fire.

The coal is screened at the mine, and several hundred tons are hauled away annually for use in the valley to the northward. No attempt has been made to test it for coking purposes.

An average specimen of the Knox & Billings Coal was forwarded to the Laboratory of the Survey and yielded on analysis (McCreath):

The coal, generally coated with a yellowish white silt, has a deep black shining lustre on fresh fracture, is rather compact, showing numerous partings of mineral charcoal.

The coal analyzed seemed quite wet.

Water,	3.260
Volatile matter,	27.860
Fixed carbon,	60.421
Sulphur,	.804
Ash,	7.655
	100.000
Coke, per cent.,	68.88
Color of ash,	Reddish gray.

The high percentage of water is due probably to nothing more than the specimen having been soaked *in transitu.*

The analysis shows a pure and good coal. It is however more nearly approaching to a gas coal than to a steam coal; the volatile matters being almost 28 per cent., which is nearly the average percentage of the Connellsville coal in Fayette county, or of the Reynoldsville coal in Jefferson county, Penn.

A drift has been run into the outcrop of a *coal bed which lies 40 feet below* the Knox & Billings coal.

The mine runs in to the south-east and drains.

The coal ran evenly and on the level for about 30 yards. It then plunged down to the southeast for several feet, and the water rose and drowned the opening.

The coal, therefore, could only be seen and measured on the south side of the main entry, and about 20 yards in from the crop. It showed:

Roof, clay slate,	—
Coal,	2′ 4″
Floor, massive sandstone,	—

The coal where examined was rather rotten and dirty; a variable slate layer, ranging from ½″ up to 2″ or more, occurs 1 foot above the floor; the massive sandstone floor, is 4′ thick, filled with impressions of fossil plants.

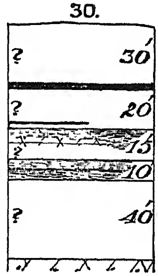
No fair specimen of the coal could be procured for analysis. At the face of the mine, the coal seemed rather harder and more compact than the Knox & Billings coal.

But the roof (clay slate) seemed treacherous, the floor of massive sandstone is very abnormal, and from the uneasiness of the coal in the short distance already opened, it would seem likely to prove an uncertain and deceptive bed.

It is reported that the coal was shafted down to near the present drift and found 4 feet thick. This, of course could not now be seen.

An imperfect section made about 1 mile from the Knox & Billings mine gave this:

30.



Surface,	—
Concealed,	30′ 0″
Coal in shaft, *reported* 3′.	
Interval, small *coal* at bottom,	20′ 0″
Micaceous sandstone and slate, and concealed,	15′
Thin slate, holding a few inches of *coal*,	10′
Interval,	40′
Massive sandstone, gray, with pebble layers coming in lower down.	
Total,	115′ 0″

The above imperfect facts represent all that were showing at the time of the examination.

The Knox & Billings coal is clearly the valuable bed of the region.

Over how great an area this bed extends could only be determined by a careful and prolonged examination. It occurs so near to the hill tops that a slight change in the geological structure would suffice to throw out or take in hundreds of acres. That it covers some considerable area is, however, very clear.

Report of Mr. Sanderson Smith.

This region was examined by Mr. Sanderson Smith, who under date of November 9, 1875, records the facts observed by him. The map which accompanied Mr. Smith's report is appended to this volume.

"Eight coal beds have so far been made out, three of which have been opened to some small extent, while a fourth may possibly prove workable.

The uppermost of these, which has a thickness of 22 inches, is the one upon which nearly all the old openings from which a supply of coal for the neighborhood was obtained in past years, were made. In 1868, when I made my first visit to the tract, an opening known as "Hurd," on Warrant 2,300, just east of the east line of 2,299, furnished all the coal then mined for sale. This was of very good quality, but the thinness of the bed, together with the fact that it is so near the highest level of the hills as to

probably underlie a very small territory, renders its value small. No coal is at present obtained from it.

Eight or nine feet below this is a bed of coal a foot thick, and three feet below this one of eleven inches. Of these, I have seen nothing but the outcrops. * * * *

Six to eight feet lower down, or twenty-one feet below the 22-inch or "Hurd Vein," comes the so-called "three-foot" or "Knox and Billings" bed, which I am inclined to consider the most valuable one yet discovered.

* * * A level has been driven easterly from the east bank of Benn Gully, and chambers excavated. At one point in this level I measured 4 feet 6 inches of good coal, with apparently only one inch or less of shale, and no visible pyrites or sulphur. Further in it was at one place only 2 feet 9 inches thick, and then widened again. I am inclined to think that its average thickness is likely to exceed rather than fall short of three feet. The quality of this coal is exceedingly good for all domestic purposes—for blacksmith's use, for the generation of steam, &c. * *

In common with all semi-bituminous coals of this region it makes a very friable coke, and is, therefore, not suited for blast furnace; and the same reason will probably prevent its extensive employment in gas making, as few gas companies are willing to employ a coal the coke from which is of no commercial value. * * * * *

Eleven feet below the "three-foot" seam, or thirty-five feet below the 22-inch bed, is a bed of about 28 inches in thickness. This bed I made an examination of in 1868, and did not then form a very favorable opinion of it. Another opening has since been made upon it, and it there presents a much better appearance, and would probably look still better if I had been able to examine a freshly cut surface, as no work has for a good while been done upon it. * *

Twenty-seven feet below this, or sixty-three feet below the 22-inch bed, is the so-called "four-foot" bed. This has been opened by a level directly below the Knox and Billings opening. In this it seems to have an average thickness of 2 feet 9 inches; but in a shaft put through it at a point not far off I am informed that it was four feet thick. The coal

from this bed seems to be of excellent quality, a little harder than that of the "three-foot" seam, and apparently applicable to exactly the same purposes, and will probably bear distant transportation somewhat better. When tried in the blacksmith's forge it gave an excellent fire. * * *

Eighteen feet below this bed is a ten-inch bed, and twenty-five below, or 91 feet below the 22-inch bed, comes a bed or series of beds, to which the name of the "five-foot" seam has been commonly given. At the "Bellows shaft," a little north-east of the Knox & Billings opening, a shaft of 14 feet depth passed through it, and a short level was driven from the bottom of this. Here the series consisted of

Coal,	1′ 0″
Fireclay,	1′ 6″
Coal,	4″ to 0′ 5″
Fireclay,	1′ 6″
Coal,	1′ 0″

Or two feet four or five inches of coal out of a total thickness of five feet four inches. At a short distance South of this, in an open cut, but where I saw no reason to think that the arrangement of the bed had been materially altered by external influences, only the upper foot of coal exists, the lower three or four feet consisting entirely of fireclay; while in a boring at the mouth of the "four-feet" level, the succession of beds was, I am told, almost exactly the same as at the "Bellow's shaft." The coal from these different openings appeared, as far as I have seen it, to be of good quality. The value of this sett of beds must, as yet, be considered quite uncertain. It is certainly not workable at the points now opened, but it is quite possible that in some other part of the lands, a large proportion of the thickness, perhaps the whole, may be found to be coal.

About 65 feet below this series of beds, or 161 feet below the 22-inch seam, comes the Conglomerate, which forms the apparent base of the Coal measures." * * * * *

These facts, as detailed by Mr. Smith, agree on the whole with the statements already made as to what is now show-

ing. That is that the Knox & Billings bed is a good bed, averaging three feet of coal; that the bed 40 feet below it *may* run to three feet of coal, and will underlie a larger acreage; and that the lower or so called "five-foot" coal may be dismissed from any calculations until it has been shown to be coal, and not coal and fireclay.

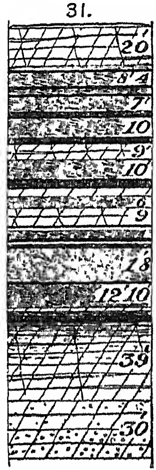
Report of Mr. Andrew Sherwood.

This same region was examined by Andrew Sherwood, Esq., of Mansfield, Tioga Co., who reports (under date of Jan., 1877,) the following facts as showing when examined by him:

"The following section, as ascertained by Mr. Baker, will show the order and thickness of the beds which constitute the one hundred and ninety feet:

Section of Coal Measures at "the Barrens."

31.



No.		
1	Brownish quartzose sandstone, weathering white, and mistaken by some for the Millstone Grist, contains carbonized stems of plants, caps the mountain	20' 0"
2.	Black slate,	2' 0"
3	*Coal,*	1' 8"
4	Dark-colored shale,	8' 4"
5	*Coal,*	1' 0"
6	Light and dark-colored shale,	3' 3"
7	*Coal,*	0' 11"
8.	Dark, sandy shale, with carbonized stems of plants,	7' 0
9	*Coal,* varies from 2' 6" to 5' 2"	3' 0"
10	Dark-colored shale,	10' 0"
11	*Coal,*	2' 5"
12	Brownish-gray and light-colored S S,	9' 0"
13.	Dark-colored shale,	10' 0"
14	*Coal,*	4' 0"
15	Gray and light-colored sandstone,	4' 0"
16.	Brownish and dark-colored clay shale,	6' 0"
17.	Gray and light-colored sandstone,	9' 0"
18.	*Coal,*	0' 10"
19	Fireclay,	2' 0"
20	Dark-colored shale,	4' 0"
21	*Coal,*	1' 9"
22	Fireclay,	1' 9"
23	*Coal,*	1' 9"
24.	Dark-colored shale,	18' 0"
25.	*Coal,*	0' 4"
26	Dark-colored shale,	12' 10"
27.	White sandstone,	1' 2"
28.	Black slate,	2' 0"
29.	*Coal,*	4' 8"
30.	Fireclay,	2' 0"
31.	Brownish sandstone, becoming a dark, sandy, slaty rock towards the top,	30' 0"
32	Millstone Grit, or hard, white quartzose, sandrock and conglomerate,	30' 0"
	Total,	223' 8"

* * * * * * Nos. 3, 5, and 7 are too thin to be considered of much importance. No. 3 is known as the "Hurd Vein." * * *

No. 9 varies in thickness from two feet and a half to five feet and two inches [Knox and Billings bed]. It is now worked to the extent of five hundred tons annually. The coal is very pure, of a dull lustre, burns with a bright

flame, and is not surpassed by any coal in Tioga county for domestic use. For some purposes in the working of steel it is said to be taken on wagons a distance of seventy-five miles.

Mr. Baker says he dug through No. 11, but the shaft having become filled up, I did not see it.

No. 14 I saw and measured myself. A drift has been cut into it for a distance of several rods. Here appears to be a vein of coal, four feet thick, of good quality, and underlying a large territory. * * *

No. 18 is too thin to be of any account.

Nos. 20 and 21 were cut through in a shaft, and the coal is said to be of good quality, but in order to work them the parting of fireclay (which may be local) would have to be mined also.

No. 29 I did not see, and therefore cannot vouch for its existence, but Mr. Baker claims to have drilled through it, and I see no reason to doubt the truth of his statement, for it is in the horizon of the three foot vein which I did see and measure in this same basin up the West Branch of Pine Creek. * * * *

The value of these coal beds is greatly enhanced from the fact that they dip slightly to the North-west on the South side of "Benn Gully," while on the North side they dip slightly in the opposite direction, or to the South-east. This is most fortunate, as Benn Gully is a branch of Long Run, and offers a good opportunity of reaching there with a railroad." * * *

Taking the facts as stated by Mr. Sanderson Smith, the facts observed personally by Mr. Sherwood and recorded by him, and the observations made during the examination for the State Geological Survey in November, 1877, and it seems clear that the Gaines Basin derives its chief importance and value from the presence of the Knox & Billings Coal bed.

The coal is clean and pure, and should be an excellent domestic fuel and a valuable steam coal; but if Mr. Smith's statement as to its non-coking character be borne out by tests, it will materially interfere with its sale to gas com-

panies—a sale which the high percentage of volatile matters would certainly secure to it, if only a valuable residual coke could be obtained from it.

The bed 40 feet below the Knox and Billings bed underlies a much larger area, and if it prove to average 3 feet in thickness, or even 30 to 33 inches, would add much to the value of the basin. It is as yet not sufficiently developed to warrant anything more definite in the way of assertion or calculation.

In character, this lower bed gives every evidence of coming up to a high standard.

The 22-inch (Hurd coal) bed, which lies above the Knox and Billings coal, may be dismissed as too small to work for shipment to market, though of good character and very regular and persistent. It only underlies the highest hill tops.

The mass of coal and fireclay called the "five-foot" bed, so far as opened up, is of no commercial value so long as it carries so much clay parting to its 2½ feet of coal.

Should it ever be opened as a clean coal bed, it would be of much consequence, and underlie the whole coal basin indicated on the maps.

The lower large coal (called 4 feet 8 inches on Mr. Baker's section) cannot enter into any estimate of the basin. It has never been shown to any of the persons examining, and from actual observation, therefore, both its size and character are unknown.

In view of the proximity of this basin to the great market of Western New York, the certain presence of a three-foot coal of good character, with another good bed probably as large, gives great importance and value to the region in the vicinity of Gaines Post Office.

The general limits of the coal are from Asaph's Run on the East to Long Run on the West. The South line is at least 1 to 1½ miles north of Pine Creek, while the North line—only approximate and not from instrumental surveys—is seen on the map to sweep around so as to narrow the basin within a width (North and South) of 1½ miles, more or less. More definite details could only be exactly ascertained by running out the outcrop lines.

It is reported that the Conglomerate of XII with the lowest coal or coals on top of it, is caught in the extreme hill tops west of Long Run, and on to Phœnix Run, and that a coal bed was once opened. This coal was not seen, but Mr. Baker reports the fact. It could cover only a small area, accessible with difficulty, and is of little practical consequence.

There appears to be no coal at all caught on the hills in the centre of the synclinal axis from Phœnix Run on westward to the Forks of Pine Creek.

But coal comes into the hills in the synclinal axis on Pine Creek, between the Main branch and the West Branch.

Pine Creek, Potter County.

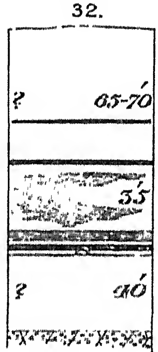
The Lower Productive Coal Measures are caught in the hills, on the continuation of the Gaines Coal Basin to the westward, in the country lying between the West Branch of Pine Creek, and the Main or East Branch of Pine Creek, in Potter county.

Coal is opened on the outcrop for examination at numerous places, and on Whittemore run it has been drifted into until solid coal was worked under good cover.

The coal opening is on the west side of the East Branch of Whittemore run, and is 690 feet (by barometer) above the Rorybacker house, on the West Branch of Pine creek at the mouth of the run, and about 2160 feet above tide.

The vertical section of the measures on Whittemore run as imperfectly exposed was thus compiled:

32.



Surface,	—
Concealed, (hold'g small coal ?),	65' to 70' 0"
Coal, (reported 2' thick.)	
Imperfectly exposed, but apparently nearly all sandy gray slates and shales,	35' 0"
Clay slate,	5' 0"
Black slates,	1' 0"
Coal,	3' 2"
Fireclay ?	2' 0"
Concealed,	40' 0"
Massive, conglomerate sandstone,	—
Total,	156' 2"

The coal reported in the upper part of the above section was not seen at all, nor has it been opened.

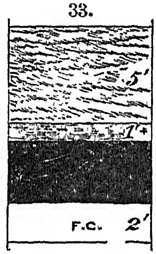
The coal 40 feet above the 3′ 2″ coal was struck in a 10 foot shaft. It is called a 2 foot bed. The pieces of it lying on the surface would indicate a hard, compact, firm, cuboidal coal, high in volatile matters.

The chief bed of the region, and the only one opened up, is the coal 40 feet above the conglomerate.

The gangway upon it runs in north 80° west. The coal dips plainly to the south-west, and the butt of the coal is north-west.

The mine was partially drowned, and the coal as examined only about 15 yards in from the crop measured thus:

33.



Clay slate,	5′ 0″
Black slate,	1′ 0″+
Coal,	3′ 2″
Fireclay floor,	2′ 0″

There are no regular slate partings in the coal bed, only occasional lenticular masses.

The coal is hard, mines out well, is jet black in lustre on fresh fracture, cuboidal in structure.

An average specimen was forwarded to the laboratory of the survey, and yielded on analysis (McCreath):

The coal, generally coated with silt, has a deep black, shining lustre on clean fracture; it is compact and firm, and has a few thin partings of slaty coal.

The coal when analyzed seemed quite wet.

Water,	3.070
Volatile matter,	30.970
Fixed Carbon,	55.140
Sulphur,	.975
Ash,	9.845
	100.000
Coke, per cent.,	65.96
Color of ash,	Cream.

The high percentage of water in the above analysis is apparently due to the coal specimen having been accidentally soaked while *in transitu.*

It is clearly an excellent coal for domestic use, and, if it will make a firm coke, is a valuable fuel for gas works' use; the percentage of volatile matters being equal to the Connellsville coal, and fully equal or superior to the Reynoldsville coal percentage of gas.

An analysis of this same coal bed (and from this mine) made by Prof. C. F. Chandler (Feb. 10, 1876,) reads thus:

Volatile combustible matter,	31.70
Fixed carbon,	56.50
Ash,	9.85
Sulphur,	1.00
Water,	0.95
	100.00

This agrees almost perfectly with the analysis of Mr. McCreath, except that the coal not being wet, Prof. Chandler gets only the normal percentage of water.

The conglomerate of XII shows below the coal (40 feet below) as a massive gray sandstone, containing numerous layers of white rounded quartz pebbles.

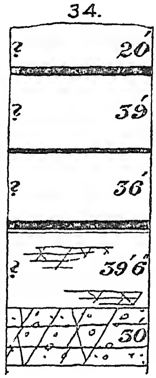
Report of Mr. Andrew Sherwood.

This Pine Creek region was examined by Mr. Andrew Sherwood in 1876, who thus reports the facts observed by him:

"The basin which I have described enters Potter county, as before stated, on the north side of Pine Creek, and crosses the North Branch above Kilbourn's Hotel, keeping on the north side of the West Branch. Two or three miles above the forks of Pine Creek are two considerable streams coming into the West Branch from the north—Whittemore Run and Beech Flat Brook. About two miles up Whittemore Run, on the west side of the right-hand fork, (or "draft," as it is here called,) I made the following observations:

Section of Coal Measures on the West Side of the Right-hand Draft of Whittemore Run.

34.



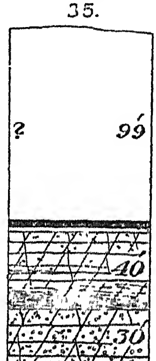
No.		Thickness
1.	Concealed from the top of the mountain,	20′ 0″
2.	*Coal*, thickness unknown, but the smut of which is 4 feet thick,	4′ 0″
3.	Concealed,	39′ 0″
4.	Coal,	2′ 0″
5.	Concealed,	36′ 0″
6.	*Coal*, into which a drift has been carried for fifty feet,	3′ 4″
7.	Fireclay,	2′ 0″
8	Concealed, probably brownish S S, becoming gray and dark-colored towards the top,	39′ 6″
9.	Millst'e Grit, a coarse hard, white and massive S. S., containing pebbles,	30′ 0″
	Total,	175′ 10″

About three-fourths of a mile from this spot, in an easterly direction, I saw a large spring cutting through No. 6. It is one of the finest natural exposures of coal in Northern Pennsylvania. The height of the hill at this point above the coal is one hundred and twelve feet. * * *

On the east side of the right-hand draft of Whittlemore Run, opposite the point where I made the foregoing section, I found the following beds :

Section of Coal Measures on the East Side of the Right-hand Draft of Whittemore Run.

35.



No.		Thickness
1.	Concealed from the top of the mountain,	99′ 0″
2.	*Coal*,	3′ 0″
3.	Fireclay, filled with roots, leaves of *neuropteris*, &c,	2′ 0″
4	Brownish sandstone, changing to a gray and dark, slaty, sandy rock towards the top,	40′ 0″
5.	Millstone Grit,	30′ 0″
	Total,	174′ 0″"

These facts agree closely with the observations made for the State Survey in 1877.

This same coal bed (the 3′ 2″ bed) has been opened for examination at numerous places in the region between Pine Creek Fork, on the East, towards Burrow's School House on the West, a distance of about 5 miles; it lies in the hills between the branches of Pine Creek, well up towards the hill tops, the elevated plateau under which it lies varying in width, ranging about 2 miles across in the centre of the basin; the basin points out to the East at the Forks of Pine Creek, and apparently on the West, at or about Burrow's School House.

The exact area of land underlaid by the coal could only be determined by running out the outcrop lines; where a coal lies so near to the hill tops a very slight widening out of valley sufficing to make great changes in acreage.

The basin lies well for mining; the coal could be easily attacked on Whittemore Run and Beech Flat Brook, and the valleys of these streams would an easy outlet to the West Branch of Pine Creek.

Taking 3 feet 2 inches to 3 feet 4 inches as the average thickness of the coal bed it will yield 5,000 tons to the acre.

Hitherto the region has been far removed from any railroad connection with a market.

The Jersey Shore and Pine Creek Railroad, upon which considerable work has been done, would pass directly by Gaines, and also by the Forks of Pine Creek, thus giving an outlet to the South to Williamsport, or to the Northwest to Buffalo and Canada.

And the proposed Geneva, Hornellsville and Pine Creek Railroad, if it should be constructed, would afford a direct route to Hornellsville, on the New York and Erie Railroad, and Geneva on the New York Central, thus throwing the coal by a short route into Central and Western New York State.

Character of the Gaines and Pine Creek Coals.

The analyses of the Gaines coal and the coal from the West Branch of Pine Creek are grouped below for convenience of reference:

	1.	2.	3.
Water,	3.260	3.070	0.95
Volatile matter,	27.860	30.970	31.70
Fixed carbon,	60.421	55.140	56.50
Sulphur,	.804	.975	1.00
Ash,	7.655	9.845	9.85
	100.000	100.000	100.000

No. 1. Knox & Billings Bed, Gaines, Tioga county.

No. 2. West Branch Pine Creek, Potter county.

No. 3. West Branch Pine Creek, Potter county. Analysed by Prof. C. F. Chandler.

It must be remembered that Nos. 1 and 2 were wet *in transitu*, and show, therefore, too high a percentage of water.

Throwing out the accidental impurities of sulphur, ash, and water, the coals show the following relationship of Volatile Hydrocarbons to Fixed Carbon:

1.	2.	3.
1—2.1687	1—1.7804	1—1.7823

And the ignitible constituents stand in the following proportion:

	1.	2.	3.
Vol. Hydrocarbons,	31.5588	35.9656	35.9411
Fixed carbon,	68.4412	64.0344	64.0589
	100·000	100.	100.

It will be at once seen that this coal is much higher in Hydrocarbons than the Blossburg or Barclay coal.

It is a *gas* coal, as well as a steam coal; and is almost identical in composition with the Reynoldsville coal from Jefferson county, which now is largely shipped to Buffalo for the gas coal trade along the lakes and in Canada.

One important question of a gas coal, namely, the character of the residual coke, this coal has not yet been tested for.

For all steam coal uses the Gaines coal can be compared with the Blossburg coal by examining the tables of Chapter XIII, of this report.

APPENDIX.

WHAT IS THE BEST OVEN FOR COKING COAL FOR FURNACE USE?

By JNO. FULTON, E. M.

General Mining Engineer, C. I. Co.
Cambria Iron and Steel Works,
JOHNSTOWN, *8, 18, '77.*

Prof. J. P. LESLEY,
State Geologist:

SIR: In a recent communication from Franklin Platt, Esq., your Assistant Geologist in this district of the State Geological Survey, he indicates what he conceives to be a present want in the important industrial department of Coking Coals for blast furnace use,—*a definite and decided opinion of the kind of oven best adapted to this purpose;* or, as he writes:—"The general nature of everything in Report L, relating to Coking is in favor of the Beehive Oven; and yet it is not so clearly or decidedly in its favor as would be the case if the book was to be written, or revised, at this time."

The published paper on Coking grew out of an inquiry into the qualities of cokes used at the Iron and Steel Works of the Cambria Iron Company, at Johnstown, Penna., instituted by Hon. D. J. Morrell, the General Manager.

It is now nearly two years since that paper was written, during which time considerable facts have been collated bearing on this important matter,—the make of coke for blast furnace use. In the former article, the statistics from the three typical methods of coking were submitted, leaving the reader, in the absence of definite proof, to draw his

own inferences as to the best kind of oven in the production of good metallurgical coke.

The present paper is, therefore, designed as a supplement to the former paper on the methods of coking, published in Report L of the Second Geological Survey of Pennsylvania,—and intended to satisfy, as far as ascertained facts will permit, Mr. Platt's effort to have the best coking oven eminently distinguished.

From the facts hitherto submitted it has been definitely settled, that certain qualities of coal are the prime elements in the production of good furnace coke. The methods of coking are secondary. If the coal is unfit for making good coke, either from impurities or lack of bituminous matter, no treatment in its coking can correct these normal defects. But, other conditions being equal, the mode of coking exerts a decided influence on the physical structure of the coke, adding to or taking from its calorific value as a furnace fuel.

It is remarkable, however, that the most desirable coking coals inherit in their normal composition the elements which give their cokes, under right oven treatment, the best physical structure for maximum calorific energy and economy in blast furnace use.

That there is a very wide range of differences in the calorific value of coals, in their application to special purposes, has been fully demonstrated. Rich bituminous coals that would give satisfactory results in generating steam, would be worthless in a blast furnace.

Hence, a careful study of each variety of coal has been made, in order that it may be applied in such a manner and to such uses as will insure the greatest efficiency and economy. In this intelligent application of particular varieties of coals to especial purposes, great care has also been taken in the examination of their chemical constituents, physical structure and calorific values. Whilst this triple attention has been given to coals and their right application clearly made out, coke has been regarded simply in two aspects,—its hardness and purity.

If it was "*dense*" with a "silvery luster" and "sonor-

ous," it was received without further scrutiny,—and no distinction made between cokes approximating these *standard* requirements. Coke was coke. And what difference should it make in furnace work if one coke differed in physical structure from another, when both inherited nearly equal volumes of carbon, ash and sulphur? But results, obtained from furnace work, clearly showed the existence of wide differences in their calorific values,—differences so marked as to make questionable the value of certain qualities of coke for furnace work.

Take, for instance, the analyses of the following cokes for blast furnace use:

Table A.

	I.	II.	III.	IV.	V.	Average Standard.
Water,	0.030	....	....	....	0.800	0.35
Volatile Matter,	0.460	....	....	....	....	0.46
Fixed Carbon,	89.576	87.58	90.48	89.28	91.106	89.06
Sulphur,	0.821	1.06	0.56	1.06	0.544	0.80
Ash,	9.113	11.36	8.96	9.66	7.550	9.33
	100.	100.	100.	100.	100.	100.

Manifestly there is little difference in the chemical elements of these cokes; from which to infer wide differences in their calorific values in furnace work.

Cokes I and IV were made in Beehive ovens,—I from coal as it came out of the mine, and IV from washed coal. These are the best qualities of cokes.

Coke II is made in Belgian ovens from coal as mined,—it also is of the best quality.

Coke III is made from washed coal in Belgian ovens. It could not be advantageously used alone in furnaces running on Bessemer pig iron. About 20 to 30 per cent. of it can be used as a mixture with Cokes I, II, IV or V. Increasing its use over these proportions will induce a cooling of the furnace with unsatisfactory work. This has been definitely settled by intelligent tests in blast furnace.

James J. Fronheiser, Esq., Superintendent of Furnaces,

C. I. Co., has recently made some interesting comparative tests of coke in one of the furnaces under his direction, at Conemaugh. This rather small furnace was run for a week on Coke I, in table A, which inherits an open cellular structure. The blast was heated to 800° F., and driven at the rate of 2600 cubic feet per minute. The ores used were mainly from Lake Superior, with some native hematite and Spanish mixtures, producing for the week 156 tons of good Bessemer pig iron.

The following week the furnace was run on a fuel mixture of ¼ Coke I, and ¾ of a coke somewhat *denser in structure* than Coke I, but in every other respect its equal. The furnace stock orherwise precisely equal during both tests, the blast was increased in volume to 3250 cubic feet per minute, to meet the increased density of the fuel. The result was a week's make of 145 tons of good Bessemer pig iron.

The consumption of coke in both weeks was 1.29 tons to 1 ton pig metal. The cokes were carefully weighed during both tests. Both cokes were made in Beehive Ovens.

The results show that under the best conditions, with the column of blast proportioned to the density of the cokes used, there is a direct loss in a week's work of 11 tons of metal, or 7½ per cent., nearly.

The test was made mainly to determine whether the proportioning of blast to the density of each quality of coke, would produce equal results. Hence, equal weights of coke to 1 ton of pig were used. The question of the relative economy of these cokes, in the quantity of each required to smelt 1 ton of pig iron was not entered into.

The test exhibits a loss of product, by the languid action of this dense coke, which, considered alone, would reduce its value from that of Coke I at least 11 per cent. *It indicates also the loss made by using in mixture in a furnace cokes of different physical properties.*

Direct tests were made at the furnaces of the Kemble Coal and Iron Co., in the Broad Top coal region, in December last, by William Lauder, Esq., General Superintendent, to determine the relative calorific values of cokes made in Beehive and Gobeit ovens, using the same quality of coal in

each kind of oven. The furnace in which the tests were made is 14'x60', with modern blowing machinery and hot blast oven. The ores are from the Clinton groupe, (No. V,) well known as the Juniata Fossil Ore, containing 30± per cent. of metallic iron. The coke is made in Beehive ovens.

Previous to this test a few Gobiet ovens were erected, from which the coke was obtained for this purpose. The increased density of coke made in this kind of oven was very manifest.

It was found that with careful management in both trials it required 2300 pounds of Gobeit coke to carry the same furnace burden as 1900 pounds of Beehive coke.

Mr. Lauder writes: "I should like to hear from you on the subject. I confess I am surprised at the results. While this coke was on the furnace it took 5196 pounds to 1 ton of pig iron. With the Beehive coke, 4156 pounds for the same work."

The loss, per ton of pig iron made, is 1040 pounds of coke, or 20 per cent. If the furnace makes 250 tons a week, the loss would be 115½ tons of coke, at \$2.25=\$259.87 per week.

On the other side two claims are made—one for the economy of labor in the Gobeit oven, the other for a larger per centage of coke from the coal.

It will be shown subsequently that an economy of 12 cents per ton does exist under the first claim, and under the second an increase in coke of 14.3 per cent., nearly—taking the product of Beehive at 63 per cent., and the Gobeit oven at 72 per cent.

Taking the weekly make of pig metal, as before, at 250 tons, and using 1.85 tons of coke to 1 ton pig iron, will require 462½ tons a week.

Then 462½ tons, saving 12 cents per ton, ...	\$55.50
Increase of coke of Gobeit oven, 14.3 per cent.=66 tons, @ \$2.25, ...	148.50
Total, ...	\$204.00

The actual loss per week would be \$259.87, less \$204.00,

equal $55.87. With the dense coke the furnace worked badly, producing an inferior pig iron.

In this case difference in the densities of the two cokes was much greater than in the cokes used at Conemaugh Furnace trials; hence the increased difference in results. Doubtless the Gobeit oven in the latter case experienced some difficulty in coking a washed coal of rather moderate per centage of bituminous matter, making the ovens run cold, and intensifying the dense structure of the coke.

But the difference, in practical furnace work, by cokes of varying physical structure, is clearly made out.

These tests have been corroborated by others pursuing the same general inquiries, but it is presumed that they are sufficient to establish the points raised in the investigation of this Coke fuel question,—*the direct effect of its physical structure on furnace work.*

In pursuing this inquiry it is important to qualify the conditions of its use in furnace work. The advantages of large cellular coke in this respect has been fully illustrated. This result assures the well known principles in furnace practice, that the more cellular the coke the smaller the volume of blast air necessary to burn it, and that the rapidity of combustion is in direct proportion to the amount of surface exposed to the action of the oxygen of the blast air. The best coke for furnace fuel should therefore possess the largest cell structure with the *hardest* cell walls possible in coke. Many cokes of medium cell structure are compensated by a columnar structure in coking and the consequent breaking up into small pieces. The undesirable cokes are therefore: 1st, Coke of a soft quality and dense physical structure; and 2d, Coke of soft or hard quality made dense by the method of coking.

There may be some exceptions in favor of a moderately hard dense coke in its use as a mixture in anthracite furnaces, as by its *density* it will bear a pressure of blast nearly equal to anthracite coal and coöperate with the latter in giving out its heat.

A mixture of this kind of coke of $\frac{1}{3}$ to $\frac{2}{3}$ of anthracite coal has been found to work advantageously in keeping the

furnace open and energysing the anthracite fuel. This exception in the use of dense hard coke in conjunction with anthracite coal does not change or modify the general law governing the production of cellular coke for blast furnace use. It only shows that medium dense coke helps anthracite coal in furnace work,—and the increased calorific energy which its presence induces would probably be still more marked in anthracite furnaces of moderate height.

The principle which requires hard cellular coke fuel for blast furnace use is in requiring a minimum volume of blast in supplying the oxygen demanded in the combustion of the fuel.

If the heat at the tuyeres in a blast furnace is taken at 3000° F. and the blast air forced through the tuyeres at 1000° F.,—then it is evident that the greater the volume of blast air necessary in the combustion of the fuel (above what is absolutely required for the oxidation of the carbon of the fuel in its best physical condition) the greater will be the cooling effect of this excess of blast air.

Hence the prime requirement in producing coke with the largest possible cell structure, so as to afford the greatest surface to the action of the blast air,—reducing the latter to its minimum volume. And in this it appears will be found the real difference of coke and anthracite coal in furnace use. Not that there is any marked difference in the heat evolved from their respective carbons; but in the superior carolific energy of the former in its rapidity and economy of combustion produced by its physical structure.

The requirements of a good coke therefore are: 1st, purity; 2nd, hardness of body; 3rd, the largest possible cell structure, limited only by its capacity to sustain the furnace burden.

Two questions follow: What is the best quality of coal for making coke? and what is the best oven for coking for furnace use?

1. *What is the best quality of coal for making coke for bast furnace use?*

The practical answer to the question is, the analyses of coals that are well known to produce the best cokes.

Table B—Analyses of typical Coals that make the best Coke.

	Connellsville Coking Coal. (McCreath.)	Bennington Seam B. (McCreath.)	Lilly's station—Coal E. (McCreath.)	Broad Top. Kelly—E. K. C. & I. Co. (Morrell.)	Ohio—Hocking Valley, Bailey's Run. (Prof. Wormly.)	Average Standard.
Water,	1.260	0.910	0.715	0.82	3.80	1.500
Volatile Matter,	30.107	26.340	22.250	18.86	32.77	26.060
Fixed Carbon,	59.616	64.373	70.518	71.12	58.10	64.750
Sulphur,	0.784	1.792	1.459	1.70	1.15	1.380
Ash,	8.233	6.585	5.058	7.50	4.18	6.310
	100.	100.	100.	100.	100.	100.

This table shows very clearly the essential requisites of coals for making first-class coke.

The relationship of volatile matter to the fixed carbon, as shown in the table, is very suggestive; although the precise *agency* of the former, in producing large cellular coke, is not yet so clearly made out.

The average percentage of fixed carbon in the coals of table B is 64.75, the volatile matter 26.23 per cent., which can be regarded as constituting an excellent coal for coking. Any excess of volatile matter over 25 per cent. is not a necessity, whilst on the other side, any large reduction from this volume must be compensated, in supplying heat for coking, at the expense of the fixed carbon, especially in cases where the coal has to be washed.

If 25 per cent. of volatile matter is taken as the standard, it will subsequently be shown that 17 per cent. would constitute a minimum in useful or economical coking; but no good furnace coke is known to the writer to have been made from coal from this small ratio of volatile matter.

That hard, dense coke can be made from such coal is a fact fully proved,—and that such coke is chemically pure for any kind of furnace work is equally well established.

TABLE C.—*Analyses illustrating the family of Dry Coking Coals, from the Lower Productive Coal Measures of the Allegheny Coal Field:*

	Smith & Co. (McCreath.)	Bed B. Unwashed. (McCreath.)	Bed B. Washed. (Morrell.)
Water at 225° F.,	.615	1.185	2.50
Volatile matter,	17.935	16.540	20.50
Fixed carbon,	76.503	74.456	73.24
Sulphur,	.602	1.860	.43
Ash,	4.345	5.959	3.33
	100.	100.	100.

Coke made from the above peculiar class of coals, whilst possessing all the essential elements of a first class fuel, yet because of very porous or *dense physical structure*, it is found in practice undesirable for furnace use. This has reference alone to the .excessive dense cokes. Cokes approaching anthracite coal in closeness of structure, but unmodified by the character of the latter in breaking up in small pieces in furnace work.

With the moderately dense cokes the blast can be proportioned to their density. The main result in the use of coke over standard density will be in the reduction of the make of metal. With very dense coke the result is not only in loss of make of metal, but in its inferior quality and general unsatisfactory working of the furnace from its characteristic soft cell walls.

II. *What is the best oven for coking for blast furnace use?*

That the mode of coking exerts a very important, though secondary influence, on the *physical character*, uniformity of quality, and dryness of the coke, has been very fully determined in furnace work. But it is questionable whether sufficient attention has thus far been given to the *physical structure* of the cokes as affected by each class of coke ovens.

The three typical families of coke ovens, the Bakers or Beehive, the Coppee, Belgian or François, and the Appolt,

all testify to efforts in the production of coke from widely different qualities of coals, without any design at enlarging or modifying the cell structure, or volatilizing a maximum of sulphur, with an objective aim at the largest percentage of product, and economy of work.

The action of each system on the *density* of the coke will be readily understood, if we conceive a brick, laid flat, to illustrate the section of chamber in the Beehive class of ovens, with its necessary shallow charge, minimum pressure in coking, and consequent maximum cellular product of coke.

If a brick is laid on its edge, it will show very accurately the posture and condition of the chamber in the Gobeit, Coppee, Belgian or François ovens, with the necessary *pressure* induced by the increased depth of charge, producing an increased density in coke.

The Appolt oven is made plain, by setting the brick on end, producing the maximum pressure on its charge, and consequently the densest coke.

Mr. I. L. Bell, however, points out the difference of the physical character of coke and its influence on furnace operations, in page 315 of his work on "The Chemical Phenomena of Iron Smelting." Reviewing the results of coke in furnace work, made in ovens of ancient and modern plans, he says: "My firm has tried these plans" (Belgian or François ovens), "but found the useful effect in the furnaces inferior to that obtained in the ordinary way (Beehives).

In consequence of this, all the more recently erected ovens have been constructed upon the old fashion; and I have endeavored to ascertain what are the circumstances which reduce the value of the commodity made according to the more modern improvements below that made in the more simple oven."*

*Hon. D. J. Morrell, who has just returned from Europe, (Oct. 1878) visited when in England, the extensive iron works of Mr. I. L. Bell's firm. He found the coke being prepared in extensive and complete *Beehive ovens*. The charge to each oven was six tons of coal yielding $3\frac{1}{2}$ tons of excellent coke, (58.2 per cent).

The practice and authority of the author of *Chemical Phenomena of Iron Smelting* are on the side *Beehive Ovens*.,

In pursuing this inquiry, he gives the results of several experiments illustrating the action of hot carbonic acid on the carbon of cokes of different physical structure, proving that it is affected in widely different degrees by the solvent power of the carbonic acid gas.

In other words, that coke can be made too hard or dense as well as too soft and open for the most useful effect in furnace operations. That a coke of intermediate physical structure, between the above, is the most desirable in yielding its heat readily, efficiently, and uniformly, thus maintaining the train of operations in the chemical reactions of the furnace which are so essential to the best results in its operations.

"Experiment 706. $2\frac{1}{4}$ grammes of hard coke, previously exposed for two hours in a covered crucible to a high temperature, was placed in a combustion tube. All air being expelled from the apparatus, a stream of thoroughly dried CO_2 was passed over the coke for 15 minutes at a red heat, and for 35 minutes at bright red (maximum of a Hofman's double furnace). Two litres of CO_2 were passed over the coke, and from this only 26 c c s of CO were collected, the remainder of the CO being unchanged."

"Exp. 708. Hard coke, pulverized to size of mustard seed, exposed at a temperature of melting zinc for three quarters of an hour to a current of CO_2, gave a mere trace of CO."

"Exp. 709. Soft coke, similarly treated as previous exp. (708), in $1\frac{1}{4}$ hours, gave 92 c c s of CO, determined by explosion with O, and absorption by KHO."

These experiments indicate very decidedly the action of carbonic acid gas on the three conditions of cokes submitted to these tests. They exhibit more especially the most desirable condition of coke for furnace use. They do not, however, embrace a wide enough range in the investigation of the physical structure of coke, for "hard coke" and "soft coke" are simply relative terms, indicating the completeness or incompleteness of the operation of coking. Reducing or pulverizing each quality of coke to the size of mustard seed, cannot represent related conditions in actual

work in the furnace, for the undesireableness of most of the dense cokes consists in part of their production in large lumps, whilst the desirable coke is produced in moderately diminutive pieces.

The prominent and conclusive fact is made out, that the make of coke in one class of ovens is not found useful in a degree warranted by the nature of its constituents, and that a different kind of oven, treating the same coal, produced a coke giving entirely satisfactory results in furnace work, under precisely similar conditions with the former.

The extremely soft, or partially prepared coke, called "black ends," would undoubtedly cause the furnace to work disadvantageously, in loss of heat by its dissolution too high in the stack.

This indicates the necessity of the uniformity of quality in the coking of fuel for persistent useful work in furnace operations.

The examples of the undesirable properties of dense coke in Conemaugh and Kemble furnaces, are sustained by very wide experiences in using too dense a fuel.

Mr. P. Doyle, L. C. E., in the "Colliery Guardian" of February last, indicates an effort recently made in British India to interest the capitalists of Bengal in the development of the native iron manufacture. In this connection the quality of coke has been entered into. "It is satisfactory to learn that in order to meet the demand which must naturally ensue, the principal coal companies in this part of India are devoting a great deal of attention to the manufacture of coke. Prominent among the companies is, of course, the East India Railway, whose resources in this respect may be approximated at nearly 50 tons per day. The quality of this coke, although considered the best in India, is not all that could be desired. Its great fault is excessive *density*, which renders it almost incombustible at ordinary red heat. The analysis yields:

Carbon,	84.09
Ash,	15.66
Sulphur,	.25
Moisture,	None.
	100.

It is added, "the defect is one that can be easily rectified," and here, just on the threshold of the most interesting inquiry, the correspondent suddenly stops! As the composition of the coal from which the coke was made is not given, it is impossible to estimate whether the objectionable *density* of the latter can be "rectified" or not. A reduction of its ash is evidently required.

A gentleman from South Russia visited the Cambria Iron Works during the past centennial year. He was in the pursuit of knowledge. A furnace with which he is connected had been put in blast, with hard Donetz anthracite coal as a fuel, composed as follows: Carbon, 95; ash, 3, and volatile matter, 2. This fuel was charged into the furnace in great "*chunks*" of one half ton or more. Under the action of heat these did not break up or decripitate, hence, wide spaces were left open for avenues to blowers, impinging on the furnace lining, and cutting it out in a little over a week's blast.

The trial was made a second time, after enveloping the new lining of furnace in a mammoth tuyere. This time the effort was continued over two weeks, terminating in the same disastrous results as in the former case.

This gentleman was advised to import an American "Coal Breaker," or procure a comprehensive assortment of sledges and hammers to break the coal into small pieces before introducing it into the furnace.

Undoubtedly the same experience would have been encountered in the use of the American variety, but for the property the latter possesses of decrepitating freely on exposure to furnace heat, thus exposing enlarged surface space to the action of the reducing gasses, and enabling it to be used with a heavy column of blast.

The breaking of larger pieces of all cokes inclined to density of physical structure has been found beneficial in furnace use. In one case a saving of 12 per cent. of fuel was obtained by breaking up the larger pieces. The denser the coke, the smaller it should be broken, in preparing it for the blast furnace.

It has been determined that the best cokes for furnace

use inherit a physical structure having the cell space to the whole mass, in the ratio of 38 to 62; and that the average of the series of best cokes would give as a standard the cell space of 36 to 64 of coke. It is also important that the cell spaces are large and well defined—easily distinguished from diminutive cells or pores.

The latter may occupy as large a space in the aggregate as the former, and yet be undesirably *dense.*

The best quality of Connellsville coal, treated in the Belgian ovens of the Cambria Iron Company, produced a coke of *very objectionable density*, especially in the *bottom* and *middle* of the charge.

The effects of the pressure, in the deep charges of this family of ovens, on the density of coke has been observed. It increases from a cell space ratio at bottom of 26 to the standard average of 36 on the section, on top.

This is very definitely shown in the coke made in the experimental Gobeit ovens, at the Kemble Furnaces, in the Broad Top Coal Region.

In coking in the primitive pits or mounds, a very full cellular structure is developed—fully equal to the Beehive in this respect. There are, however, two objections to this mode of coking: 1st. It produces irregular work, a portion of its coke is soft or "black ends;" and, 2nd. That it is the most expensive of the systems under review. For uniform, economical work, in coking coal for blast furnace use, it cannot be strongly recommend. Yet under careful management, in mild dry weather, it has given results, on the whole, fairly satisfactory.

The inquiry as to the best *oven*, will be confined to a comparison of the Beehive and Belgian.

The Appolt being regarded as planned for peculiar cases which are not embraced in the limits of the present investigation.

The advantages of the Beehive are mainly as follows: 1st. It produces from the coal the best possible physical structure of coke; 2nd. It yields a uniform quality of coke; 3d. Its coke watered out in the oven is produced in the driest condition; 4th. In rabbling it out it is separated

into diminutive pieces; and 5th. The operation of coking in it is simple, and the cost of oven and repairs moderate.

The Belgian or François oven has its advantages: 1st. It produces a uniform quality of coke; and 2d. It is the most economical method of coking.

Its disadvantages consist mainly, with the ordinary coking coals, in making a *dense* coke. It requires skill in its coking operations. It requires its coke to be quenched outside in a clumsy manner, producing a damp fuel. Its cost is large, but its repairs moderate.

It is only especially adapted to the family of coals demanding pressure in coking, to prevent too inflated a physical structure, and to the peculiar cases hitherto noticed, consisting of coals holding a minimum of volatile matter and requiring washing. It may be urged, however, that the coke from this class of coals, holding a small percentage of the cell making matter in its composition, is so *dense* as to be undesirable for metallurgical purposes, and doubtless this is true. But the question arises, whether mixtures of cokes of different densities in a blast furnace are economical, since the blast cannot be proportioned to the densities of the fuel and must therefore be a compromise with its consequent waste. But in the coking of such coal, a mixture of more bituminous coal might be introduced, enabling it to be coked in Beehive ovens with an improved open structure of coke.

The relative cost of making coke in each kind of oven is hereby given, with original cost of ovens and annual cost of repairs. The estimate contemplates banks of ovens to produce 100 tons of coke per day or 30,000 tons per year. Coal at $1 per ton delivered at ovens.

Beehive Ovens.

80 ovens at $200=	$16,000
Interest on investment 10 per cent. per annum .	1,600
Annual repairs and renewals at $10=	800

Then $\frac{\$2400}{30,000 \text{ tons}}$ = 8 cents per ton of coke.

Cost of Coal and Coking.

1.60 tons of coal @ $1 per ton	$1 60
Labor at ovens, charging and drawing	27
Interest on cost of ovens and annual repairs . .	8
Coal, $1 60; coking, &c., 35 cents. Total= . .	$1 95

Belgian Ovens.

65 Ovens at $700 each	$45,000
Engine for pushing coke out of ovens	3,000
Annual repairs to engine	50
Tracks for engine	300
Annual repairs to ovens	310

Annual interest on investment ($48,800) at 10 per cent., $4,880.

Then $\$4,800+\$310+\$50=\frac{\$5,240}{30,000 \text{ tons.}}=17\frac{1}{2}$ cents nearly.

Cost of Coal and Coking.

Coal 1.42 tons @ $1 per ton	$1 42
Labor at ovens, charging, luting, pushing, &c. .	23½
Interest on cost of ovens and annual repairs . .	17½
Coal, $1 42; coking, &c., $0 41. Total=	$1 83

The Belgian plant of ovens is the more costly in construction, but less expensive in repairs and coking.

The economy in this class of ovens, consists in the saving in coal to make 1 ton of coke; the saving in the work of discharging the coke out of ovens and in their annual repairs.

The Beehive oven is less costly in construction but more expensive in annual repairs. Regarding the two systems in the aspect of absolute economy, embracing the interest of invested capital in their construction, with annual repairs of each, and without any reference to the value of the coke made by each kind of oven, the Belgian exhibits an economy of 12 cents per ton of coke in its favor.

But, estimating the ultimate results of each quality of

coke, in blast furnace work, and embracing all the factors demanded in its physical and chemical condition to insure uniform work, maximum calorific energy and economy, the *Beehive* oven is regarded as possessing the greater number of good properties. That it is susceptible of improvement is self-evident, in the utilization of expelled gases, especially at the commencement of the operation of coking, by introducing flues under the floor of the oven. But in all subsequent changes, the main principles of Beehive coke making should be retained—shallow charges, uniform work, and quenching the coke so as to produce it crispand dry.

The Belgian or François oven will retain its place of usefulness in coking certain qualities of coals: (*a*) The very pitchy or bituminous coals which agglutinate readily and swell in bubbles of abnormal size.

(*b*) The dry burning coals of the north west and west, known generally as "block coals."

(*c*) And in coking a third class of coals, it may be found a necessity—the coals that are low in volatile matter, 17 per cent.± If these are found in a sufficiently pure state to be coked without washing, then the Beehive oven would be the proper method of treatment; but when they require washing, and are charged into the oven in a damp condition, the Belgian oven alone, it is believed, could support the necessary heat by its swift method of discharge of coke and immediate charge of coal into the hot oven chamber.

In the work of comparing the calorific values of the several qualities of cokes, by the "Bell Standard," the make of 1 ton of No. 3 pig iron from 40 per cent. Cleveland iron stone, with 2.408 pounds (1.075 tons) of coke, and blast heat at 932° F., it will be evident that great modifications will be required in the amount of fuel per ton for smelting the several qualities of iron ores, and that this quantity of fuel is not alone determined by the chemical composition of the ores, or their richness in iron, but also by their *molecular structures*. In the pursuit of this inquiry, an important member is greatly needed—the "co-efficient of fusibility" of each quality of the most useful and com-

monly used iron ores, in the heat units required for the reduction of a fixed quantity of each.

The whole matter of the selection and right preparation of mineral fuel for blast furnace operations, at this time, when the rapidly increasing use of coke is elevating its manufacture amongst the important national industries, becomes a study of the utmost importance, because of its prime influence not only on the quality and economy of the pig metal, but on the improved qualities of its widely extended products in iron and steel, enhancing their values in home use, and enabling the manufacturer to enlarge his operations by a successful competition in the marts of the world.

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Devonian Sections East and West of the Tioga River.

(made in 1841, and published in Final Report, Vol. I. p. 310.)

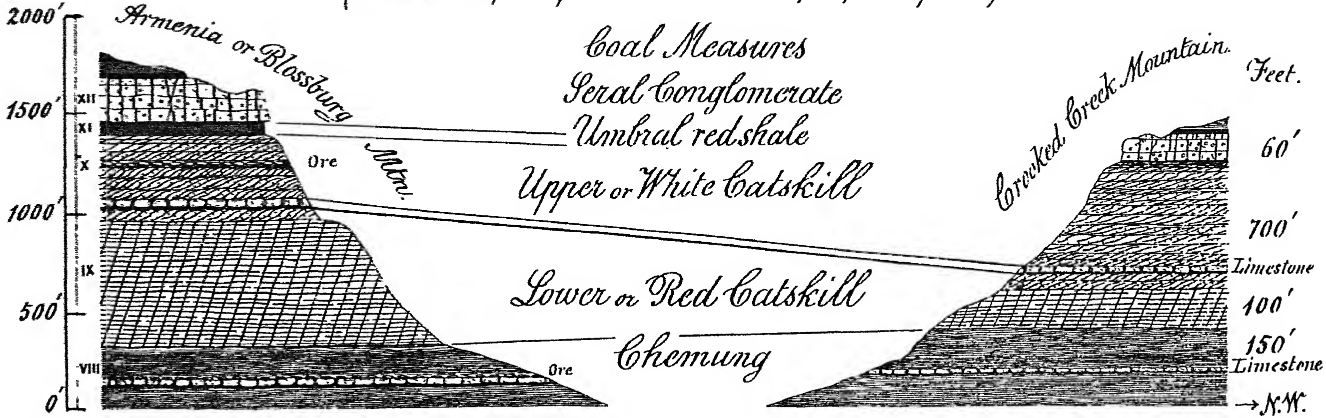

Diagram Section in Bradford Co. Pa.   Diagram Section in Tioga Co. Pa.

Note. These diagrams do not represent the actual heights of the Towanda and Blossburg mountains, as such; but the several average thicknesses of the formations (VIII, IX, X, XI, XII,) measured at right angles to the dip; and they include with the rocks of the mountain all the rocks of the valley to the crown of the anticlinal. The spectator is supposed to look from the northeast

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